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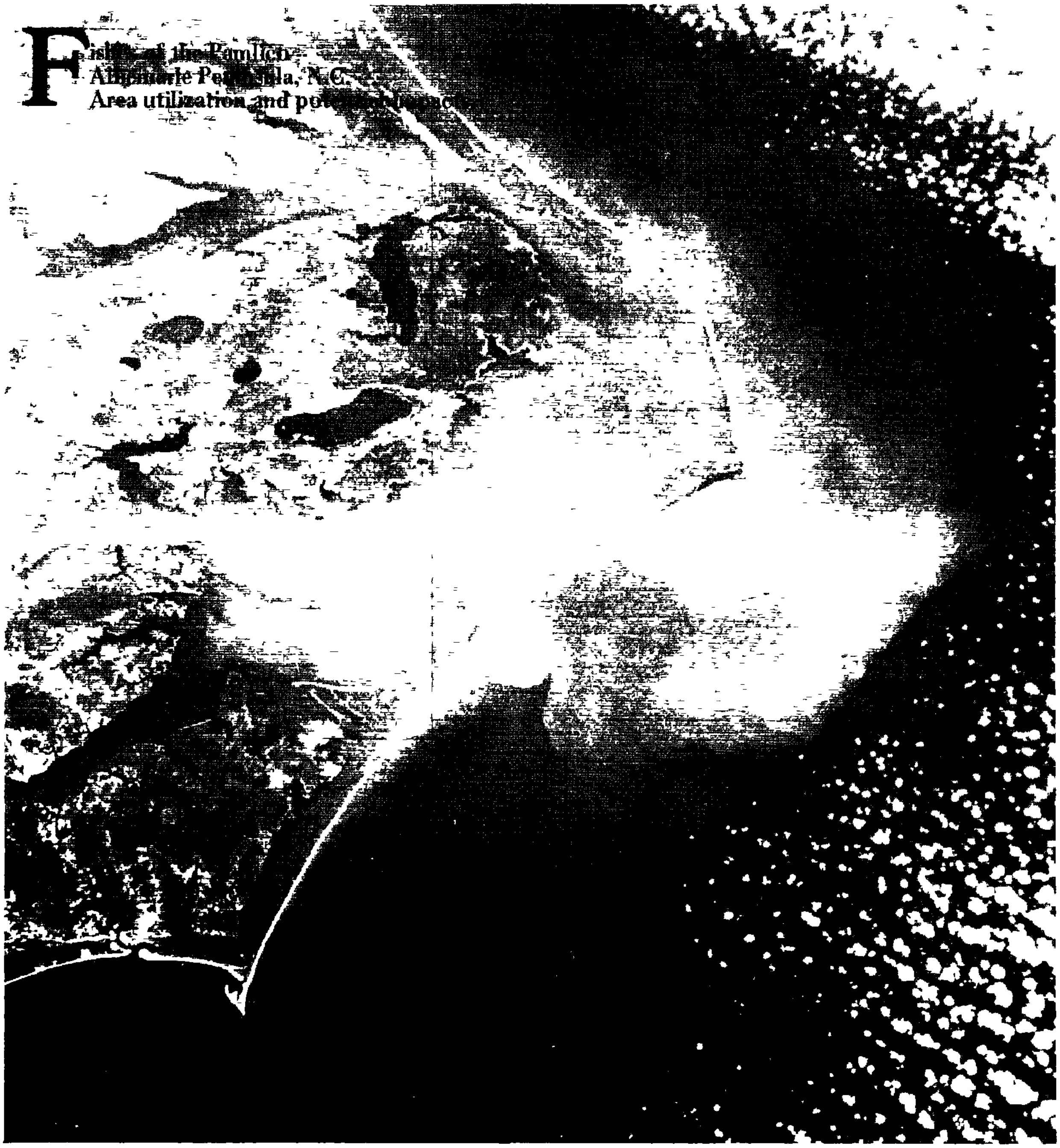
Fisheries of the Pamlico-Albemarle Peninsula, N.C.: Area utilization and potential impacts



North Carolina Department of Natural Resources and Community Development • Division of Marine Fisheries

SPECIAL SCIENTIFIC REPORT NO. 42
CEIP REPORT NO. 23 1984

FISHES OF THE PAMLICO-ALBEMARLE PENINSULA, N.C.

AREA UTILIZATION AND POTENTIAL IMPACTS

by

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ABSTRACT

Fisheries data from the Pamlico-Albemarle Peninsula, N.C. were compiled and digitized as part of the North Carolina Division of Marine Fisheries biological monitoring database. Four species of commercially important invertebrates and 132 species of fish were collected on the peninsula, usually across a broad range of salinities. Seven life history strategies were illustrated by the nekton. Most species were transient primary freshwater or marine species but the migratory marine species were the most abundant.

Spatial and temporal partitioning of the waters of the peninsula were evident. Primary freshwater species, freshwater transients, and anadromous species were most abundant in the oligohaline waters of Albemarle Sound, the upper Pungo River and Lake Mattamuskeet, and in the limnetic inland lakes. Migratory marine species, marine transients, and estuarine residents, except white perch, were more abundant in the mesohaline waters of Pamlico Sound. Distributions of some species indicated differences between northern and western Pamlico Sound basins. Some species such as weakfish were more abundant in deeper water whereas others such as the spottail shiner and atherinids were inhabitants of the shallow nearshore environment; some were pelagic (e.g. Atlantic menhaden) while others were benthic (e.g. brown shrimp). Utilization of the estuarine nursery areas was intense and simultaneous for several species groups. Recruitment was high in the spring (spot, croaker, brown shrimp, river herring), and in the summer (white perch, white catfish, weakfish, silver perch).

More than 90% of North Carolina's commercial fisheries landings are comprised of estuarine dependent species. The Pamlico-Albemarle Peninsula provides a diverse habitat for estuarine nekton and is one of the most productive nursery areas in the state. Changing land use practices on the peninsula could significantly alter the productivity of the area. Assessment of impacts, however will be difficult until we have a consistent database and know more about environmental stress and the role of advective processes and biologically relevant abiotic factors.

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INTRODUCTION

Over one-half of the U.S. commercial fisheries catch is comprised of estuarine dependent species. The proportion of estuarine dependent species in the North Carolina landings is much higher than the national average, exceeding 90% annually (Ross and Epperly in press). North Carolina's largest estuary or lagoon is the Pamlico-Albemarle Sound system encompassing an area of 6,630 km² (2,560 mi²) (Gross 1972); it is the third largest in North America.

The Pamlico-Albemarle Peninsula is a 4,232 km² (1,634 mi²) land mass situated between Albemarle Sound to the north, Croatan Sound to the east, and Pamlico River and Sound to the south (Figure 1). Within this area is the largest continuous wetland in the state and one of the largest in the nation (Heath 1975). The area is relatively flat, low and swampy with the majority of the wetland less than 3 m (10 ft) above sea level. Two-thirds of the area, mostly in the eastern half, is less than 1.5 m (5 ft) above sea level (Heath 1975). Natural drainage into the surrounding sounds is provided primarily by overland drainage into Mackeys (Kendricks) Creek, Scuppernong and Alligator rivers to the north, and Pungo River and Pamlico Sound embayments to the south. The water table is close to the surface and consequently during wet periods saturation occurs quickly. Because of the land's relatively flat profile, overland runoff moves very slowly, often requiring days or weeks.

Artificial drainage on the peninsula began in the late 1600's to allow for agricultural production, and periods of active land development have continued to the present (Skaggs et al. 1980). The latest period of increased activities began in the early 1970's, raising concerns about the effects of land development, particularly on the rate and distribution of runoff and hence on the water quality of the surrounding sounds and their fisheries production.

Fishery resources are important to the economy of the peninsula and to the state. The dockside value of landings in Beaufort, Dare, Hyde, Tyrrell and Washington counties has averaged greater than $18 million over the last five years, or more than one third of the value of the state's edible seafood landings (Table 1). A large proportion of the

Table 1. North Carolina commercial marine fisheries landings (in thousands of pounds and dollars) 1962-1983 for Beaufort, Dare, Hyde, Tyrrell, and Washington counties. Landings data do not include menhaden or thread herring and county data prior to 1978 do not include unclassified non-edible landings. Landings by species and gear are given in Appendix A and B, respectively. North Carolina general canvas data from the N.C. Division of Marine Fisheries and the National Marine Fisheries Service.

	County										Totals			
	Beaufort		Dare		Hyde		Tyrrell		Washington		Counties of the Pamlico-Albemarle Peninsula		North Carolina	
Year	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
1962	3,186.8	352.3	8,199.2	708.6	1,135.0	370.4	657.6	66.0	683.1	26.1	13,864.0	1,523.3	59,486.0	6,754.0
1963	3,892.8	302.1	9,294.7	766.9	1,443.6	208.3	612.2	63.0	404.9	25.0	15,659.0	1,365.4	66,438.0	7,045.0
1964	4,415.7	407.6	12,692.7	1,103.7	1,653.5	256.7	271.3	36.4	329.4	30.6	19,582.5	1,835.3	65,587.0	5,744.0
1965	5,577.6	492.1	12,559.5	1,372.4	1,883.1	269.4	318.4	33.2	318.6	28.5	20,658.4	2,200.7	72,291.0	7,155.0
1966	3,855.8	455.5	11,398.6	989.6	3,384.8	305.9	664.3	80.1	330.5	45.7	19,647.6	1,877.0	66,061.0	6,998.0
1967	3,538.0	422.5	9,216.8	953.2	2,970.1	280.0	657.2	84.6	493.0	69.5	16,895.1	1,809.6	68,300.0	6,565.0
1968	3,936.8	557.0	10,548.5	1,340.6	3,311.4	574.8	1,339.8	131.0	888.1	163.5	10,024.6	2,776.8	62,262.0	7,713.0
1969	4,387.8	649.7	10,504.9	1,483.8	5,784.3	1,214.4	1,012.1	123.1	408.8	66.8	22,077.1	3,537.5	69,357.0	10,237.0
1970	5,655.1	551.3	9,055.7	1,247.1	4,781.1	654.6	1,091.0	154.8	232.4	36.4	20,815.3	2,644.2	60,046.0	7,711.0
1971	4,219.5	612.7	9,066.8	1,489.2	2,944.1	913.6	1,656.0	146.6	295.8	43.4	18,182.2	3,205.6	57,705.0	10,003.0
1972	2,790.0	589.4	9,565.8	1,505.3	2,448.7	531.4	1,068.0	131.4	270.8	38.1	16,143.1	2,795.7	69,695.0	10,253.0
1973	2,971.6	733.5	11,699.0	2,175.3	2,224.9	615.9	1,130.6	146.4	269.6	32.8	18,295.7	3,743.9	67,205.0	13,357.0
1974	3,437.3	733.6	14,254.4	2,470.0	3,633.5	924.5	778.6	92.7	368.4	66.0	22,153.4	4,297.8	81,081.0	14,475.0
1975	3,801.8	916.7	16,372.4	3,706.6	3,203.7	769.9	765.7	143.1	604.3	87.8	24,327.8	5,203.5	77,654.0	16,519.0
1976	5,936.9	2,202.9	20,122.3	5,017.9	2,875.6	939.0	748.8	200.4	597.3	123.7	30,308.6	8,403.8	80,160.0	22,453.0
1977	5,864.9	1,983.4	18,411.5	5,035.1	4,393.4	1,604.0	1,001.7	240.1	484.9	110.9	30,756.8	8,973.6	88,251.0	24,099.0
1978*	4,735.9	1,525.1	22,563.7	9,083.6	8,327.5	1,885.7	1,729.1	440.3	533.4	126.6	37,888.9	13,061.4	105,547.0	33,042.0
1979*	7,147.1	1,941.9	34,564.2	12,987.8	8,014.8	2,040.3	1,250.1	276.6	380.1	68.9	51,354.4	17,315.6	117,382.0	49,935.0
1980*	6,867.8	2,732.9	41,585.0	13,731.2	13,055.7	4,182.0	976.1	228.3	531.7	100.2	63,016.3	20,974.5	153,805.0	61,391.0
1981*	6,895.2	2,006.4	39,421.9	12,893.0	10,251.8	2,956.5	1,466.2	328.0	824.7	134.6	58,859.7	18,318.5	121.666.0	47,453.0
1982*	5,552.4	2,446.7	32,476.7	12,999.0	9,537.1	3,457.3	1,535.8	361.4	1,138.7	150.3	50,240.7	19,414.6	120,869.0	58,049.0
1983*	4,729.2	1,944.5	27,018.2	9,387.3	9,190.4	3,632.1	1,637.1	455.5	827.7	95.7	43,402.6	15,515.0	106,746.0	51.140.0

*Preliminary landings. Data subject to revision in the Fishery Statistics of the U.S.

state's primary nursery areas designated by the North Carolina Marine Fisheries Commission are located along the southern perimeter of the peninsula (Figure 1). The low salinity waters of the peninsula serve as spawning and nursery areas for anadromous fish species (Figure 1) (Street and Pate 1975; Marshall 1976; Johnson et al. 1977; Johnson et al. 1981). Decreased fisheries production due to alteration of fisheries habitat on the Pamlico-Albemarle Peninsula could potentially affect the economy of the peninsula and of the state. It was therefore important to assess the status of the fisheries resources on the peninsula in order to evaluate potential impacts.

MATERIALS AND METHODS

Data Sources

There are several sources of fisheries data for the peninsula. The U.S. Fish and Wildlife Service has collected data in the Mattamuskeet National Wildlife Refuge and the Pungo National Wildlife Refuge at irregular intervals since the mid 1900's. Their efforts were usually short term and the results were not published. In summer 1964 the Inland Fisheries Division of the North Carolina Wildlife Resources Commission surveyed the waters of the Pamlico-Albemarle Peninsula (Bayless and Shannon 1965; Smith and Baker 1965). The same Division also visited Lake Phelps in 1965 and 1976 and established trawl stations in the lake during 1978 (Kornegay and Dineen 1979). Environmental Science and Engineering, Inc. (ESE) sampled the upper Pungo River on four occasions between November 1981 and February 1983 to conduct a preliminary assessment for Peat Methanol Associates (Environmental Science and Engineering 1982a,b, unpubl. data).

The North Carolina Division of Marine Fisheries (DMF) began preliminary surveys of anadromous resources in Albemarle and Croatan sounds and tributaries during 1972 and sampled established stations monthly from 1973 through 1978; areas east of the Scuppernong River were sampled only in September or October in subsequent years (Street and Pate 1975; Johnson et al. 1977; Johnson et al. 1981; Winslow and

Sanderlin 1983). The purpose of this survey was to identify anadromous fish nursery areas and monitor juvenile populations. Seines have been used throughout the survey, but in July 1974 the wing trawl replaced the 1.8 m (6 ft) Cobb trawl that was used initially. This survey also included sampling in the open waters of Croatan Sound, Alligator River, Bull Bay and southern Albemarle Sound during 1972-1974 using a 3.0 m (10 ft) Cobb twawl (Hester and Copeland 1975; Street and Pate 1975). In 1982 a semi-balloon trawl was used at two Albemarle Sound stations. This juvenile anadromous fish survey was extended to include the Pungo River area during 1974-1975 and continued at much reduced levels in the Pungo River through 1977 (Marshall 1976, Division of Marine Fisheries, unpubl. data). In the Pungo River survey a 3.2 m (10.5 ft) flat trawl was used in addition to the seine and the wing trawl. Tow times and gears were not consistent and occasionally a trawl was pulled at the surface. Anadromous fish spawning areas on the peninsula have been identified through: 1) the capture or observation of running ripe females, 2) the observation of spawning activity, or 3) the capture of eggs or larvae (Street and Pate 1975; Marshall 1976; Johnson et al. 1977; Johnson et al. 1981).

The DMF began a monthly survey of northern Pamlico Sound (excluding Pungo River) nursery areas using a 3.2 m (10.5 ft) flat trawl in 1974 which continued until Fall 1975 (Purvis 1976). The area was sampled with reduced effort until 1978 when a statewide juvenile stock assessment survey (including Pungo River) was somewhat standardized (Carpenter 1979; Carpenter and Ross 1979; Ross 1980a; Ross and Carpenter 1983; Hawkins 1982); tow times were standardized in 1979, and beginning in 1981 actual lengths were measured instead of modal lengths. Stations sampled with a 6.1 m (20 ft) flat trawl were added in 1978 and in 1981 the tailbag mesh size of this trawl was changed from 19.0 mm (0.75 in) bar mesh to 6.4 mm (0.25 in) bar mesh, effectively changing the profile of its catches. Juvenile stock assessment stations on the peninsula sampled with the 3.2 m (10.5 ft) flat trawl were invariably in shallow water in narrow, upper stream areas with silt and clay sized substrate. Stations sampled with the larger trawl were in deeper, more open waters.

A project to investigate the effects of freshwater drainage was conducted by the DMF during 1977-1980, in Rose and Swanquarter bays

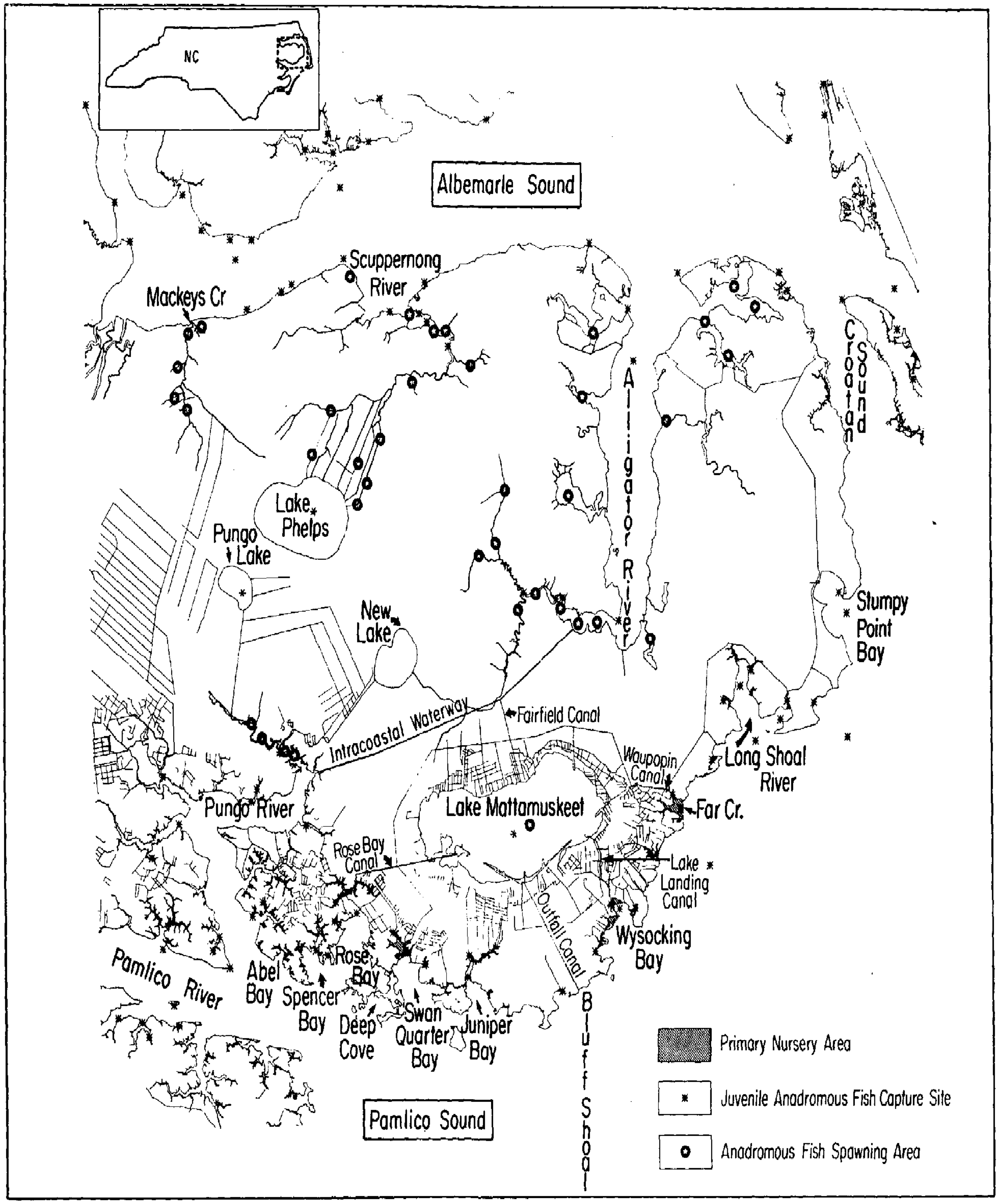

Figure 1. North Carolina primary nursery areas and anadromous fish spawning and nursery areas located on the Pamlico-Albemarle Peninsula.

(Pate and Jones 1981; Jones and Sholar 1981). Stations indicative of altered and unaltered environments were sampled with the 3.2 m (10.5 ft) flat trawl two or three times a week during May-October.

Other fisheries collections have been made on the peninsula. In 1979 North Carolina State University staff and students under the direction of Dr. John Miller began sampling Rose Bay (Gerry 1981; Woodward 1981; Sutherland 1982; Currin 1984; Miller et al. in press). Nine stations were sampled with the 3.2 m (10.5 ft) flat trawl at two week intervals in 1979 and twice a year thereafter. In 1982 and 1983 intensive effort was concentrated in East Rose Bay Creek. The emphasis in 1982 was on species' distributions as related to salinity and in 1983, on predator-prey relationships. Allen et al. (1979) made collections at Durants Island in 1979, and during 1978-1981 the Inland Fisheries Division conducted a food habits study of piscivorous fishes in Lake Phelps (Kornegay 1981).

Data Analysis

Data were coded and digitized as a part of the DMF biological monitoring data file (Epperly 1984), and analyzed using SAS version 82.3 (SAS Institute 1982a, b). Because of the differences in the various sampling programs several analytical problems were incurred and resolved in the following manner:

1) Data from programs which did not include information on all species of the catch were not used quantitatively.

2) Taxa not identified to species were eliminated from the analyses.

3) All non-commercial invertebrates were eliminated from the analyses because of identification problems and lack of consistent data on their occurrence.

4) Several species identifications were changed, especially in the Inland Fisheries 1964 stream survey data. _Fundulus diaphanus_ (banded killifish) was totally absent in survey reports for the peninsula but was probably misreported as _F. ocellaris_, which in this area is now considered a junior

synonym of F. pulverus (bayou killifish). F. pulverus is a relatively rare species in North Carolina and was not reported from any other collections on the peninsula. Individuals are sexually dimorphic with female F. pulverus resembling F. diaphanus. The records of F. pulverus were analyzed as F. diaphanus. F. stellifer (southern studfish) is endemic to the Alabama and Chattahoochee river systems of Georgia and Alabama, but was reported in the Inland Fisheries stream surveys. Because of the rare likelihood of this species occurring on the peninsula it was coded as Fundulus sp. Native populations of Lepomis megalotis (longear sunfish) are west of the Appalachians. It was unlikely that this species was introduced despite the Inland Fisheries stream survey record and therefore it was coded as Lepomis sp. Paralichthys dentatus (summer flounder) and P. lethostigma (southern flounder) were both reported in the 1964 survey but P. dentatus was the more abundant species and was reported in the lowest salinities. This is opposite of the DMF's findings throughout the state. Because it was likely that the species were confused in the 1964 survey, flounder data from those surveys were analysed as Paralichthys sp. Citharichthys arctifrons (Gulf Stream flounder) is an offshore marine species generally found in depths exceeding 100 m (328 ft). The record of C. arctifrons from the peninsula is probably invalid and was a misreported C. spilopterus (bay whiff), a relatively common species in the higher salinity areas of the estuary which was notably absent from the survey's species list. Gobionellus stigmaticus (spottail goby) was analyzed as Gobionellus sp. Verified records of Gobionellus stigmaticus in North Carolina are restricted to the southern area of the state (Gilbert and Randall 1979). Records of Etheostoma nigrum (johnny darter) on the peninsula were changed to E. olmstedi (tessalated darter). Menhinick (1975) reported the distribution of Etheostoma nigrum as restricted to the northern central area of the state whereas E. olmstedi is distributed throughout the state east of the Appalachians, but overlaps with *E. nigrum* in four areas.

5) Depending on the program, actual lengths of a representative species subsample may have been measured, but frequently only a range or modal lengths were recorded. When other than a range of lengths were recorded, lengths were expressed as frequencies of 10 mm modal groups.

6) All gill nets were analyzed as one gear regardless of type, size and set times and given an effort of one unit for each station sampled. This was necessary because type, size or set information was frequently missing and because of the difficulty in comparing efficiency between two different nets.

7) All seines were analyzed as one gear regardless of type and size and given an effort of one unit for each haul. Again, frequent lack of specific gear details precluded comparing different seines. However, the majority of seine effort was with a 28 m (60 ft) bag seine.

8) Because the area or volume of water sampled was usually not recorded, all rotenone collections were assigned a single unit effort for each station rotenoned.

9) Trawl effort was the number of minutes towed.

Two insurmountable problems were the lack of consistent data from the same gear throughout the entire peninsula and inconsistent sampling effort with the same gear. Seventeen unique gears were used to sample the fishes of the peninsula (Table 2). Gears have different efficiencies for different species and sized individuals. Surveys were designed for target species and different surveys did not sample with the same gear. Even data collected by the same trawl towed for different amounts of time cannot be standardized (per unit effort) and compared because nekton species are distributed randomly throughout a uniform area but individuals of a species are aggregated (Leaman 1981). For example, data from a 0.5 minute tow cannot be multiplied by two to estimate what the catch would have been if the trawl had been towed for one minute. Although the anadromous fish survey in the Albemarle Sound had consistent gear, tow durations, and sampling frequencies during 1974-1978, tow times with a different gear in the Pamlico Sound juvenile stock assessment survey were not consistent until 1979. There are no

Table 2. Distribution of sampling effort in each of the major sounds and lakes of the Pamlico-Albemarle Peninsula.

Gear (effort unit)	Sound				Lake			
	Albemarle Sound	Croatan Sound	N. Pamlico Sound	W. Pamlico Sound	Lake Phelps	New Lake	Lake Mattamuskeet	Pungo Lake
Fyke net (sets)							2	
Gill nets (sets)	4		1	56			38	7
Seines (hauls)	369	115	4	139			35	1
Cast net (stations)							3	
Trawls (minutes):								
surface towed-								
1.8m Cobb trawl		10.0						
3.2m flat trawl	30.0			4.5				
7.9m wing trawl				102.0				
bottom towed-								
1.8m Cobb trawl	3,396.0	440.0						
3.0m Cobb trawl	1,258.0	135.0						
3.2m flat trawl		17.0	1,471.3	3,976.5				
4.9m flat trawl				15				
6.1m flat trawl (19.0mm bar tailbag)			737.0	1,094.0				
6.1m flat trawl (6.4mm bar tailbag)		50.0	550.0	890.0				
6.1m semi-balloon trawl	1,041.0							
7.9m wing trawl	5,796.5	735.0		37.0	1,140.0			
Rotenone (stations)	36		5	41	6	1	25	7
Electric shocker (stations)					2			

years of overlap between the consistent (within survey) samples in the two areas.

Species' catch-per-unit-efforts (CPUE) were calculated for each unique gear by adding the number of individuals collected of a species and dividing the sum by the total amount of effort expended by that gear. Although not valid for quantitative analyses, the resulting CPUE should illustrate trends and differences among areas or gears.

For analyses, the peninsula was divided into broad geographic areas and further divided into drainages of similar characteristics or in close proximity. These areas are described in the following pages. Sampling sites are shown in Figure 2.

Albemarle Sound

Albemarle Sound is a drowned river valley isolated from the Atlantic Ocean by the Outer Banks. Outflow from Albemarle Sound is relatively large (490 m^3/s or 17,300 ft^3/s) creating sufficient flow to effectively block saline water entering through Oregon Inlet (Giese et al. 1979). Because of the large distance to the nearest inlet, lunar tidal amplitude is dampened and overshadowed by wind tides. It is an oligohaline body of water (Hester and Copeland 1975) encompassing an area of 1820 km^2 (703 mi^2) and averages 4.5-6 m (15-20 ft) in depth (Roelofs and Bumpus 1953). Bottom sediments grade from fine sand along the southern shore to silts and clays in the central basin (Pels 1967). The shorelines of Washington County are primarily low bank and swamp forest with some high bank whereas Tyrrell County shorelines are predominately low bank and secondarily swamp forest (Copeland et al. 1983).

Sampling effort in the sound consisted of 51.2 hours towed with the wing trawl, 10.6 hours towed with the 1.8 m (6 ft) Cobb trawl, 12.8 hours towed with the 3.0 m (10 ft) Cobb trawl, 17.4 hours towed with the semi-balloon trawl, and 224 seine hauls. Most stations have been sampled consistently since 1973.

Mackeys Creek (Kendricks Creek)

Mackeys Creek is a small tributary which receives heavy agricultural drainage. Except for a small sandy beach at the mouth, the main creek is bordered by swamp forests. The predominant land use of surrounding areas is agriculture but a wooded buffer was retained along the banks of the creek. Depths at the mouth average 2 m (5-6 ft) but rapidly decrease to less than 1 m (2 ft) in the farm land areas. This tributary was sampled at three rotenone stations in 1964 by the Inland Fisheries Division and in 1972 by DMF with four tows made with the 1.8 m (6 ft) Cobb trawl.

Scuppernong River

The Scuppernong River is a lower coastal plain stream lined by swamp forests (McDonald and Ash 1981). Depths range from 2.4 to 4.6 m (8-15 ft) and the bottom is mostly mud and detritus (Street and Pate 1975). The Scuppernong River area includes Bull Bay. In 1964 Inland Fisheries rotenoned seven stations and set gill nets at one. The DMF has made 130 seine hauls, and trawled for 15.4 hours with the wing trawl, 5.6 hours with the 1.8 m (6 ft) Cobb trawl and 3.1 hours with the 3.0 m (10 ft) Cobb trawl. Four stations in the river and bay (two seine and two wing trawl) have been sampled consistently since 1974.

Alligator River

The shorelines of Alligator River are bordered primarily by swamp forest and pocosins, although a low bank with a sandspit occurs at the mouth on the western shore (McDonald and Ash 1981; Peacock and Lynch 1982; U.S. Army Corps of Engineers 1982). The river between Kilkenny Landing and New Lake Fork is bordered by freshwater marsh (McDonald and Ash 1981). The Alligator River was divided into six areas as described below:

Alligator River north of the highway 64 bridge

This area includes Little Alligator River and East and South lakes and was sampled by Inland Fisheries with nine rotenone samples and one gill net set in 1964 and by the DMF during 1972-1974. Effort during the

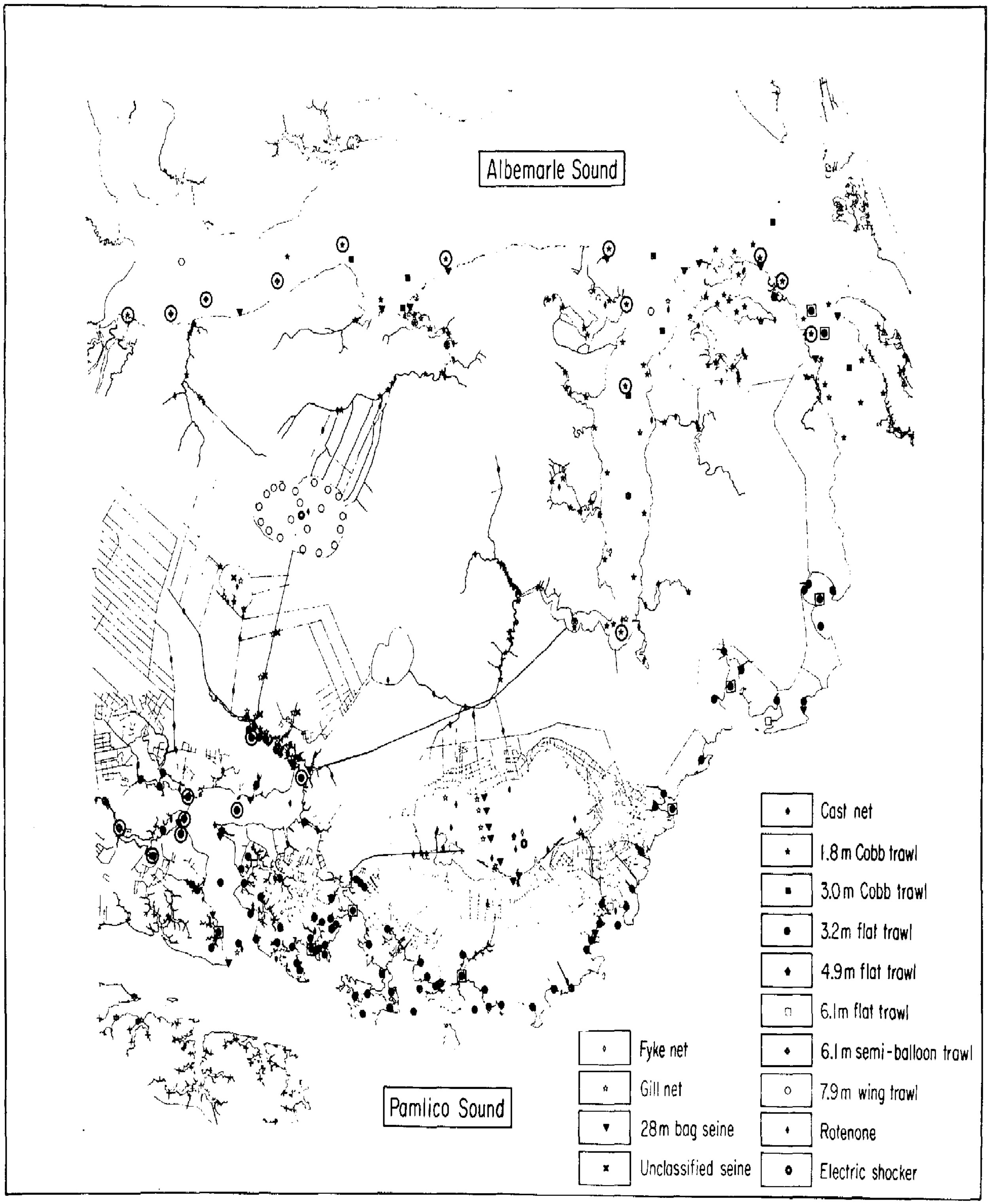

Figure 2. Sampling locations on the Pamlico-Albemarle Peninsula.

1972-1974 period included 19.2 hours towed with the 1.8 m (6 ft) Cobb trawl, 2.3 hours towed with the 3.0 m (10 ft) Cobb trawl, and 15 seine hauls. One station in Little Alligator River was continued as a wing trawl station and has been sampled for 6.3 hours.

Alligator River between the highway 64 bridge and the Frying Pan Straits/Stumpy Point

This area includes Second Creek and the Frying Pan to the west and Milltail Creek to the east. The area was sampled by the DMF with the 1.8 m (6 ft) Cobb trawl in 1972 for a total of 5 hours. Inland Fisheries rotenoned five areas and set one gill net in 1964. During 1972-1973, 2.6 hours were trawled with the 3.0 m (10 ft) Cobb trawl. One station in the middle of the river has been sampled since 1972 changing from a 1.8 m (6 ft) Cobb trawl station (3.3 hours of effort) to a wing trawl station in 1974 (5.8 hours of effort).

Alligator River between Frying Pan Straits/Stumpy Point and a line connecting Newport News Point and marker R"10"

Stations in the river, and in Whipping Creek and Lake were sampled by the DMF in 1972-1973 with the 1.8 m (6 ft) Cobb trawl, expending 8 hours of effort. Sampling at a single station in the river was continued after 1973 with the wing trawl (5.8 hours of effort). Inland Fisheries rotenoned five stations within this area, including two in Swan Creek and Lake and set one gill net in the river.

Alligator River between Newport News Point/marker R"10" and the Northwest Fork Alligator River

The intracoastal waterway connecting the Pungo River joins Alligator River within this area. In 1972-1973 DMF stations were sampled for 4.2 hours with the 1.8 m (6 ft) Cobb trawl. Two stations were retained after 1973 and sampled with the wing trawl (12 hours of effort). Inland Fisheries rotenoned and set a gill net at one location in 1964.

Alligator River above the Northwest Fork

The DMF sampled this area in 1972 with the 1.8 m (6 ft) Cobb trawl (0.5 hours of effort) and Inland Fisheries rotenoned three sites in 1964.

Northwest Fork Alligator River

This area includes the Northwest and Southwest forks which drain the upper Alligator River Pocosin. The DMF sampled four stations in 1972 (0.4 hours) with the 1.8 m (6 ft) Cobb trawl. Inland Fisheries rotenoned three sites in 1964.

Croatan Sound

Croatan and Roanoke sounds connect Albemarle Sound to Oregon Inlet and the more saline waters of Pamlico Sound. Croatan Sound differs from the portion of Albemarle Sound already discussed in that it is a relatively small body of water emcompassing 120 km^2 (46 mi^2) (Roelofs and Bumpus 1953) and is bordered by brackish marsh. Water depths are generally shallow, seldom exceeding 3 m (10 ft). Only mainland or open water samples from Croatan Sound are included, as all Roanoke Island stations are not within the area considered in this report.

Preliminary juvenile anadromous fish sampling in 1972-1973 by the DMF used a 1.8 m (6 ft) Cobb trawl (7.3 hours) and a seine. The 3.0 m (10 ft) Cobb trawl was used to sample an open water station from April 1972-June 1974 and was towed for a total of 2.3 hours. After 1973 two wing trawl stations and two seine stations were retained. The wing trawl was towed for 12.3 hours. Seines were hauled in the sound 115 times. In 1983 four stations were added in Croatan Sound for the DMF juvenile stock assessment program conducted in Pamlico Sound and other North Carolina estuaries to the south. Two of the stations were trawled with the 3.2 m (10.5 ft) flat trawl and two were trawled with the 6.1 m (20 ft) flat trawl for a total effort of 0.2 and 0.8 hours, respectively.

Pamlico Sound

Pamlico Sound and adjacent tributaries cover an area of 4350 km^2 (168 mi^2) and form the second largest estuarine system in the United

States. It is a large, bar-built embayment consisting of a complex of drowned river valleys. This lagoonal area is separated from the ocean by barrier beaches breached by the small and shifting Oregon, Hatteras and Ocracoke inlets. The Tar-Pamlico and Neuse rivers are the major sources of freshwater inflow, which can be periodically high, but on a long-term basis Pamlico Sound's hydrography is dominated by tidal (oceanic) and wind (lagoon) generated flow (Giese et al. 1979). Depths are very shallow with a maximum of 7.5 m (25 ft).

Bluff Shoal divides Pamlico Sound into two basins (Folger 1972; Giese et al. 1979). Division of Marine Fisheries data (Ross and Epperly in press) illustrate distinct biological patterns north and west of the shoal indicating a real separation of the sound, at least during some seasons. Because of the potential differences between stations on either side of the shoal, fisheries data were analyzed by basin.

Pamlico Sound North of Bluff Shoal

Stumpy Point Bay

Stumpy Point Bay differs from other northern Pamlico Sound embayments because it has no natural tributaries. Stations were located in the deep channel of the bay; station depths ranged from 2.4 to 4.6 m (8-15 ft). The area was sampled by the DMF for nursery area delineation and juvenile stock assessment with the 3.2 m (10.5 ft) flat trawl. One 3.2 m (10.5 ft) flat trawl station was continued after 1977 and one nursery area station was changed to a 6.1 m (20 ft) flat trawl station in 1978. Effort for the 3.2 m (10.5 ft) trawl was 4.1 hours, and was 2.4 hours and 1.8 hours, respectively, for the 6.1 m (20 ft) trawl with the large and small mesh tailbag.

Parched Corn Bay, Long Shoal River, Otter Creek

Numerous nursery area stations were sampled in these areas by DMF beginning in 1974. Juvenile stock assessment stations sampled after 1978 (four 3.2 m (10.5 ft) flat trawl stations and two 6.1 m (20 ft) flat trawl stations) did not include samples in Parched Corn Bay, and Otter Creek sampling was conducted only in 1983. A single seine haul was made in March 1978. Effort in these areas included 8 hours towed with the 3.2 m (10.5 ft) flat trawl, 5 hours towed using the 6.1 m (20 ft) flat trawl with the large mesh tailbag and 3.6 hours towed using the same trawl with the small mesh tailbag.

Far Creek, Middletown Anchorage, Brooks Creek

These areas have been sampled by DMF since 1974, although only two stations have been sampled consistently with the 3.2 m (10.5 ft) flat trawl. The site in Brooks Creek was sampled for nursery area designations in 1974-1975, but was sampled in the juvenile stock assessment program only in March 1983. Far Creek stations were generally located in the channel; an open water 6.1 m (20 ft) trawl station was added in 1978. Effort in these areas included 4.8 hours towed using the 3.2 m (10.5 ft) trawl, 2.5 hours towed using the 6.1 m (20 ft) trawl with the large mesh tailbag, and 1.9 hours trawled by the 6.1 m (20 ft) trawl with the small mesh tailbag. Inland Fisheries rotenoned one site in Middletown Creek in 1964.

Wysocking Bay

Inland Fisheries rotenoned one site each in Wysocking Bay and Lake Landing Canal during their stream survey of 1964, and the U.S. Fish and Wildlife Service made a gill net set in Lake Landing Canal in July 1982. The DMF began nursery sampling in 1974, continuing two 3.2 m (10.5 ft) flat trawl stations after 1976 and adding a 6.1 m (20 ft) flat trawl station in 1978. The 3.2 m (10.5 ft) flat trawl station in Hickory Creek was sampled only in 1982. Trawling effort in Wysocking Bay included 5.1 hours by the 3.2 m (10.5 ft) flat trawl, 2.4 hours by the 6.1 m (20 ft) trawl with the large mesh tailbag and 1.8 hours by the 6.1 m (20 ft) trawl with the small mesh tailbag. Three seine hauls were made during March - May 1978.

Outfall Canal, East Bluff Bay

The Outfall Canal is a drainage outlet for Lake Mattamuskeet. Inland Fisheries rotenoned two sites in the canal in 1964 and the DMF sampled a 3.2 m (10.5 ft) flat trawl station at its mouth during 1974-1977. A second station established in Harbor Creek in 1974 is still sampled. The 3.2 m (10.5 ft) trawl was towed 2.5 hours in this area.

Pamlico Sound West of Bluff Shoal

West Bluff Bay, Cunning Harbor, Juniper Bay

Inland Fisheries rotenoned a single site in Judges Quarter Canal during their 1964 survey. The DMF nursery area stations sampled with the 3.2 m (10.5 ft) trawl were established in 1974; two stations in Juniper Bay were retained and sampled consistently as juvenile stock assessment stations, one as a 6.1 m (20 ft) flat trawl station. Two stations, one in Cunning Harbor and one in Buck Creek, were sampled in 1982 and 1983, respectively, with the 3.2 m (10.5 ft) flat trawl. Trawl effort was 4.8 hours using the 3.2 m (10.5 ft) trawl, 2.4 hours using the 6.1 m (20 ft) trawl with the large mesh tailbag and 1.8 hours using the 6.1 m (20 ft) trawl with the small mesh tailbag.

Swanquarter Bay

One site in Swanquarter Bay was rotenoned in 1964 by Inland Fisheries. Several DMF nursery stations were established in 1974, three of which were continued as juvenile stock assessment stations with one of those stations changing to a 6.1 m (20 ft) flat trawl station. An additional nursery area station in Eastern Bay was sampled as a juvenile stock assessment station 1982. In 1977 three stations, one of which was a former nursery area station, were established for the freshwater drainage project and were sampled through 1980 with the 3.2 m (10.5 ft) flat trawl. Trawl effort totalled 13.6 hours for the 3.2 m (10.5 ft) flat trawl, 2.3 hours for the 6.1 m (20 ft) flat trawl with the large mesh tailbag, and 1.9 hours for the 6.1 m (20 ft) flat trawl with the small mesh tailbag.

Deep Cove, White Perch Bay

Four DMF nursery area stations were sampled in this area; none except the Blowout station sampled in 1982 were retained as juvenile stock assessment stations. The 3.2 m (10.5 ft) flat trawl was towed for a a total of 2.0 hours in this area.

Rose Bay

Three rotenone samples were taken by Inland Fisheries in 1964 and a site in Rose Bay Canal was rotenoned and sampled with a gill net by the U.S. Fish and Wildlife Service in July 1982. Several nursery area stations were established by DMF in 1974; three were retained and sampled consistently as juvenile stock assessment stations, one as a 6.1 m (20 ft) flat trawl station. In addition, the Broad Creek and Lightwood Snag Bay stations were sampled in 1982 and 1983, respectively. Freshwater drainage project stations were established in 1977 in Rose Bay and Tooley creeks. Cumulative trawl effort was 20.1 hours for the 3.2 m (10.5 ft) flat trawl, 2.1 hours for the 6.1 m (20 ft) flat trawl with the large mesh tailbag and 1.8 hours for the 6.1 m (20 ft) flat trawl with the small mesh tailbag.

Spencer Bay

Long Creek was rotenoned in 1964 by Inland Fisheries. In 1974 DMF began nursery area sampling in the Spencer Bay area and retained two stations in Germantown Bay for juvenile stock assessment, one as a 6.1 m (20 ft) flat trawl station. Sampling of the 3.2 m (10.5 ft) flat trawl station was discontinued after 1982. In 1978 an additional juvenile stock assessment station was established as a 3.2 m (10.5 ft) trawl station and sampled in subsequent years. Three additional juvenile stock assessment stations in Spencer Bay were sampled in 1982 and 1983: one in 1982, one in 1983, and one in both years. Two freshwater drainage project stations were located in Swan Creek. Cumulative trawl effort was 7.5 hours for the 3.2 m (10.5 ft) trawl, 2.0 hours for the 6.1 m (20 ft) trawl with the large mesh tailbag and 1.8 hours for the 6.1 m (20 ft) trawl with the small mesh tailbag.

Abel Bay, Crooked Creek

Two sites in Abel Bay were established by DMF as nursery area sampling stations and continued in the juvenile stock assessment program, although one was sampled with a 6.1 m (20 ft) flat trawl in the latter program. The juvenile stock assessment station in Crooked Creek was sampled only in 1983. Inland Fisheries rotenoned one site in Abel

Bay during their 1964 stream survey. Cumulative trawl effort was 2.4 hours for the 3.2 m (10.5 ft) flat trawl, 2.3 hours for the 6.1 m (20 ft) trawl with the large mesh tailbag and 1.9 hours for the 6.1 m (20 ft) trawl with the small mesh tailbag.

Pungo River from mouth to Field Point/Sandy Point

The Inland Fisheries took four rotenone samples and set one gill net in the lower Pungo. The DMF conducted anadromous and juvenile stock assessment surveys in the area and, except for two seine stations, the 3.2 m (10.5 ft) flat trawl was used exclusively in this area during the anadromous fish survey and at the Warner Creek station during both surveys; cumulative effort for this gear was 4.4 hours. One seine station from the 1974-1975 anadromous survey was retained in the juvenile stock assessment program through 1979; 40 seine hauls were made. The 6.1 m (20 ft) flat trawl was used at the juvenile stock assessment program stations in Fortescue and Wrights creeks and accounted for 4.7 hours of effort for the trawl with the large mesh tailbag and 3.7 hours of effort for the trawl with the small mesh tailbag.

Pungo River from Field Point/Sandy Point to Durants Point/Windmill Point

In their 1964 stream survey, Inland Fisheries rotenoned one site each in each Jordan Creek, Slade Creek and the Pungo River. The DMF made 11 seine hauls at an anadromous survey station in the river and towed the 3.2 m (10.5 ft) flat trawl at anadromous fish stations in the river, and in Slade, Fishing and Jordan creeks. The Wood Creek anadromous station was continued in the juvenile stock assessment program; an additional station sampled with the 6.1 m (20 ft) trawl was established in Slade Creek in 1978. Cumulative trawl effort was 3.2 hours for the 3.2 m (10.5 ft) flat trawl, 2.4 hours for the 6.1 m (20 ft) flat trawl with the large mesh tailbag and 1.8 hours for the same trawl with the small mesh tailbag.

Pantego Creek, Pungo Creek

Inland Fisheries rotenoned 5 and 4 sites in Pantego and Pungo creeks, respectively. The 3.2 m (10.5 ft) flat trawl, and 7.9 m (26 ft) wing trawl were used to sample most anadromous fish stations in the two creeks. A seine station and 3.2 m (10.5 ft) flat trawl station in Pungo Creek were sampled in both the anadromous fish and juvenile stock assessment surveys, but the seine and trawl stations were discontinued after 1980 and 1981, respectively. Trawl effort in these creeks was 4.3 hours for the 3.2 m (10.5 ft) flat trawl towed on the bottom, 0.4 hours for the bottom towed wing trawl, 3 min for the surface towed 3.2 m (10.5 ft) flat trawl and 1.7 hours for the surface towed wing trawl. Seines were hauled 43 times.

Pungo River between Durants Point/Windmill Point and highway 264 bridge at Leechville

Eight sites were rotenoned by Inland Fisheries in 1964, and on 3 occasions in 1981 and 1982 Environmental Science and Engineering sampled two sites in the river for Peat Methanol Associates using gill nets, the 3.2 m (10.5 ft) flat trawl and/or a 4.9 m (16 ft) flat trawl. The DMF sampled the river and tributary creeks with the 3.2 m (10.5 ft) flat trawl, the wing trawl and seines for the anadromous fish program. The seine station in the river and two trawl stations in Scranton and Upper Dowry creeks were also sampled in the juvenile stock assessment program, although the seine station and Upper Dowry Creek trawl station were discontinued after 1979 and 1981, respectively. Seines were hauled 40 times, gill nets were set 6 times, the 3.2 m (10.5 ft) trawl was towed for 4.3 hours, a 4.9 m (16 ft) flat trawl was towed (by ESE) for 5 minutes, and the wing trawl was towed for 10 minutes.

Pungo River above Leechville

Rotenone was used by Inland Fisheries to sample two sites in the river and the DMF sampled three stations in the river with the 3.2 m (10.5 ft) trawl and used the wing trawl at one. ESE visited the river on four occasions during 1981-1983 and sampled several stations in the river with gill nets, a 4.9 m (16 ft) flat trawl or the 3.2 m (10.5 ft) trawl. They also used gill nets in Clark Mill Creek and Canal D, and five seine hauls were also made in the latter. A total of 41 gill net sets were made and trawl effort was 1.0 hour for the 3.2 m (10.5 ft) trawl, 10 minutes for the 4.9 m (16 ft) flat trawl and 1 minute for the wing trawl.

Inland Lakes

The Pamlico-Albemarle Peninsula contains four natural lakes which, under natural conditions, were landlocked. Lake bottom altitudes exceed sea level in all lakes except Lake Mattamuskeet (Heath 1975). All four lakes are at least partially surrounded by a ridge of land which was likely formed with sand and silt eroded from the lake bottom and probably represents the pre-drainage canal extents of the lakes (Heath 1975). Attempts to lower the water levels of these lakes began with the completion of a canal connecting Lake Phelps and the Scuppernong River in 1787. With monies provided by the State Literary Board in the late 1830's, drainage canals for Mattamuskeet (Lake Landing Canal), New and Pungo lakes were completed (Heath 1975). Physicochemical data for each lake were given in Heath (1975).

Lake Phelps

Lake Phelps is a 65 km^2 (25 mi^2) natural lake of relatively clear water whose northern border is the Pettigrew State Park. The lake's perimeter offers a flooded woodland/aquatic macrophyte fisheries habitat in contrast to the barren sand/mud bottom which comprises most of the midlake (Kornegay and Dineen 1979). The maximum depth is approximately 2 m (7 ft) but the average depth is 1.5 m (5 ft) (Heath 1975). The area analyzed as Lake Phelps included the lake itself and all canals around its perimeter, including those connecting the lake to the Scuppernong River.

In their 1964 stream survey, Inland Fisheries rotenoned a site in both Moccasin (Western) and Batava canals. In June of the following year the same Division returned to rotenone two sites in Lake Phelps. They also rotenoned an area in the northeast corner of the lake in their March 1976 visit. An electric shocker was used at the same site and along the southern shore in the March 1976 sampling. In November 1976, they sampled 12 stations within the lake using the wing trawl (10 minute tows) and during April through October 1978 sampled 20 stations at night, monthly with the same trawl. In addition, angling, electrofishing and gill nets were used to supplement the monthly trawl catches for a piscivorous game fish food habits study (Kornegay 1981). Effort with the wing trawl was 19 hours.

New Lake (Alligator Lake)

New Lake is a shallow lake with a mean depth of 1 m (3 ft) and a surface area of 19.9 km^2 (7.7 mi^2) (Heath 1975). Natural drainage was towards the Alligator River. Turbidity is high in the lake because of erosion of the hard, black clay bottom. Fisheries data from the lake is represented solely by one rotenone sample taken by Inland Fisheries in 1964.

Lake Mattamuskeet

Lake Mattamuskeet is the largest natural lake in the state encompassing an area of 172.8 km^2 (66.7 mi^2) (Heath 1975). Natural drainage was to the north, towards the Alligator River. Depths in the lake average less than 1 m (2.5 ft) and the bottom is predominantly sand (Heath 1975). Since the completion of Lake Landing Canal in 1838, other canals connecting the lake to Pamlico Sound (Waupopin, Outfall, and Rose Bay canals) and Alligator River (Fairfield Canal) have been dug. In 1913 the lake was drained via an extensive network of canals, ditches and a pumping station for agricultural use of the fertile bottom. In 1933 the ambitious project was abandoned and in 1934 the lake and adjoining land was purchased to form the Mattamuskeet National Wildlife Refuge. The lake has been managed since for waterfowl (Heath 1975). The earliest fisheries data were collected in 1901, and Huish (1979) summarized sources of Lake Mattamuskeet fisheries data through 1979.

The U.S. Fish and Wildlife Service made seine collections in the lake in June 1949 and 1956. In July 1958 and October 1959 a variety of gears including seines, gill nets and rotenone were used, but data were not reported by gear. Rotenone and gill nets were used in their August 1961 visit to the lake. In 1964 Inland Fisheries rotenoned areas in Fairfield and Carters canals. Beginning in 1965 the North Carolina Cooperative Fisheries Unit under the direction of Dr. F. E. Hester sampled the lake. In May 1965 rotenone and seines were used while in October of the same year gill nets were set and during October through

December 1966 gill nets, rotenone and seines were used. The unit visited the lake nearly monthly, sometimes more frequently, February 1967 to June 1969 using the same gears and supplementing with cast and fyke nets. The U.S. Fish and Wildlife Service set gill nets in the lake in July 1982 and used seines and rotenone in the canals and management impoundments. Effort for the above mentioned collections totalled 35 seine hauls, 25 rotenone sites, 38 gill net sets, 2 cast net samples and 3 fyke net sets.

Pungo Lake

Pungo Lake is the smallest of the peninsula's natural lakes, encompassing a surface area of 11.4 km^2 (4.4 mi^2) (Heath 1975). Although once landlocked, the lake's natural drainage was towards the Pungo River. The lake's drainage was hastened by drainage canals dug between 1839 and 1843 and the depth of the lake now averages less than 1 m (3 ft) (Heath 1975). Because of the area's peat deposits turbidity is high and pH is low (Boaze 1980). The lake and surrounding lands were incorporated as the Pungo National Wildlife Refuge in 1963.

The area analyzed as Pungo Lake includes the lake, the Pungo Lake Canal and the canals within the refuge. Two rotenone samples were taken in 1964 in the Pungo Lake Canal by Inland Fisheries and in May 1965 the U.S. Fish and Wildlife Service rotenoned two sites in the lake (one in the center and one along the shore), set experimental gill nets in the center, and seined along shore. They returned to the refuge in July 1980, rotenoning two sites in the lake and one site in the Duck Pen Road Ditch, and set gill nets in the lake and surrounding canals. In July 1982 they recorded temperature and pH at 17 sites within the lake and canals. Effort in this area totalled seven rotenone stations, one seine collection, and seven gill net collections.

RESULTS

Hydrography

Water temperatures on the Pamlico-Albemarle Peninsula closely follow air temperatures with maxima typically occurring in late summer and minima occurring in January (Giese et al. 1979). Salinities are less variable but follow a seasonal cycle of reduced salinities in the early spring as a result of heavy winter runoff and higher salinities in the late summer coincident with reduced summer runoff. Winds dominate the short term horizontal patterns of salinity distribution (Roelofs and Bumpus 1953).

Nekton collections on the peninsula were taken in salinities ranging from 0-30.2 $^{o}/oo$, although most effort was expended in waters of less than 18 $^{o}/oo$ (Table 3). Salinities were highest in Pamlico Sound and tributaries (Figure 3) and averaged 2-3 $^{o}/oo$ higher at stations north of Bluff Shoal than at stations located west of Bluff Shoal. Mean salinities of the Pungo River area below the highway 264 bridge and of Croatan Sound were in the lower mesohaline range, whereas Albemarle Sound and tributary waters and the upper Pungo River were oligohaline. Lake Phelps, New Lake and Pungo Lake were essentially fresh water but salinities in Lake Mattamuskeet, when measured, were high enough to classify that lake as oligohaline.

Nekton of the Pamlico-Albemarle Peninsula

Collections on the Pamlico-Albemarle Peninsula have yielded four species of commercially important invertebrate nekton and 132 species of fishes (Table 4). Eleven species accounted for more than 95% of the total number of individuals captured and three of those species (bay anchovy, spot and Atlantic menhaden) together accounted for greater than 75%. Most species were collected across a broad range of salinities (Table 5), but distributions relative to salinity are difficult to discern because effort was not distributed equally across the range of salinities encountered (Table 3).

Life History Strategies

Seven life history strategies were represented by the nekton collected on the peninsula (Table 6). Few species were collected strictly in freshwater and, in most instances, these were represented by single individuals. Three species of this group, *Lepomis microlophus*, *L. cyanellus* and *Ictalurus melas*, are not endemic to the area (Lee et al. 1980); it is uncertain whether the Lake Phelps occurrence of the endangered *Fundulus waccamensis* represents a fourth introduction (Shute

Table 3. Distribution of sampling effort across discrete salinity zones.

Gear (effort unit)	Salinity Zone Limnetic 0-0.5 ‰	Oligohaline 0.5-5.0 ‰	Lower Mesohaline 5.0-10.0 ‰	Upper Mesohaline 10.0-18.0 ‰	Lower Polyhaline 18.0-25.0 ‰	Upper Polyhaline 25.0-30.0 ‰	Euhaline 30 ‰
Fyke net (sets)	2						
Gill nets (sets)	45	3	1				
Seines (hauls)	222	238	94	26			
Cast net (stations)	3						
Trawls (minutes):							
surface towed-							
1.8m Cobb trawl	10.0						
3.2m flat trawl			1.0	0.5			
7.9m wing trawl	35.0	13.0	8.0	7.0			
bottom towed-							
1.8m Cobb trawl	2,030.0	270.0	20.0	10.0	20.0		
3.0m Cobb trawl	560.0	603.0	75.0	20.0	10.0		
3.2m flat trawl	51.0	486.0	1,579.5	2,706.5	254.5	2.0	
4.9m flat trawl							
6.1m flat trawl (19.0mm bar tailbag)		275.0	822.0	574.0	75.0		
6.1m flat trawl (6.4mm bar tailbag)	5.0	115.0	245.0	880.0	190.0		
6.1m semi-balloon trawl	640.0	205.0					
7.9m wing trawl	3,796.0	3,064.0	502.5	173.0	10.0		
Rotenone (stations)	45	37	15	10	4	1	1
Electric shocker (stations)	2						

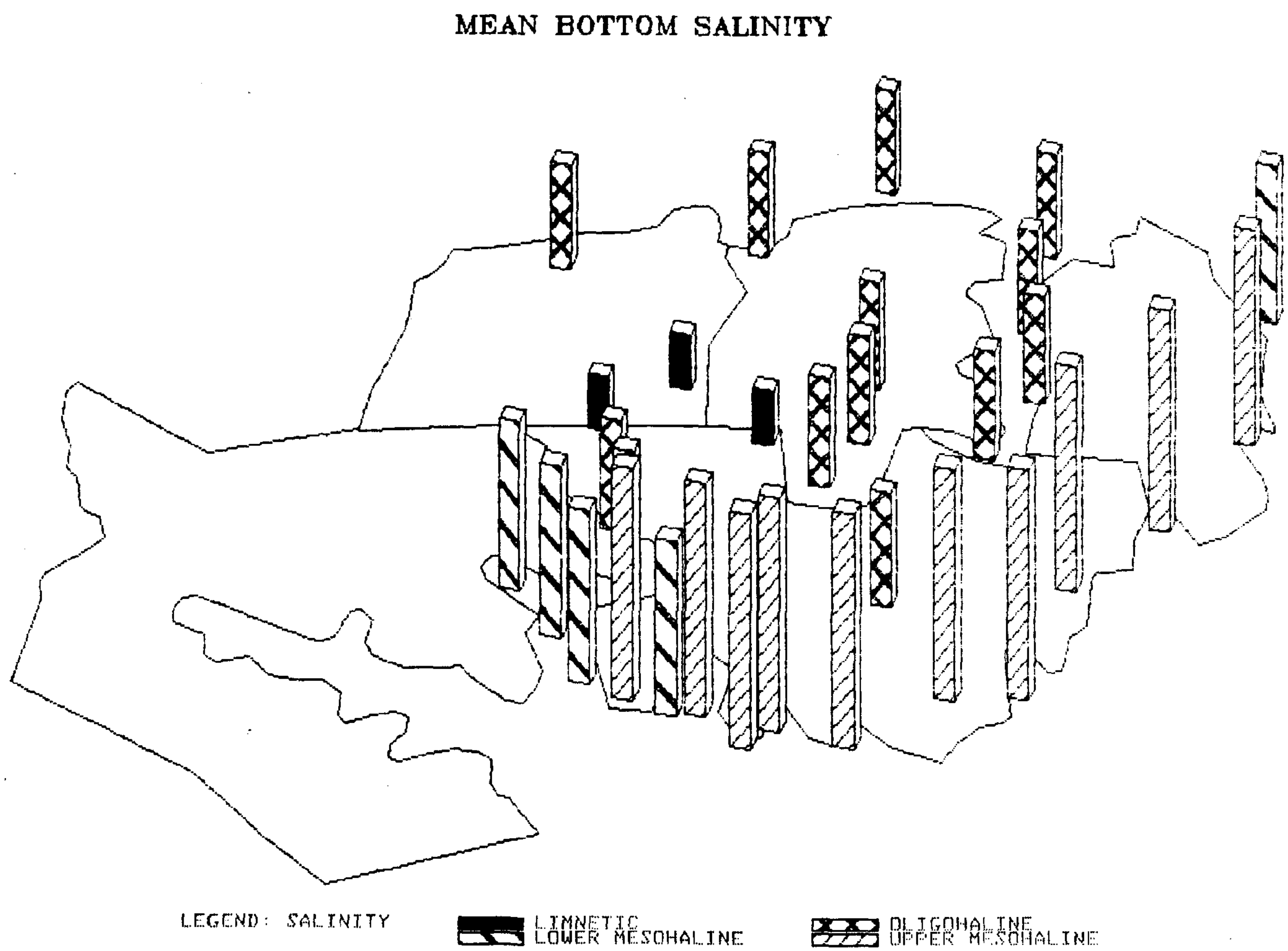

Figure 3. Mean bottom salinities on the Pamlico-Albemarle Peninsula.

Table 4. Nekton species collected in each of the major sounds and lakes of the Pamlico-Albemarle Peninsula. Numbers of individuals captured are indicated for each species.

	Sound				Lake			
Species	Albemarle Sound	Croatan Sound	N. Pamlico Sound	W. Pamlico Sound	Lake Phelps	New Lake	Lake Mattamuskeet	Pungo Lake
Penaeus aztecus	14	169	20,675	34,075				
Penaeus duorarum	1	106	2,314	704				
Penaeus setiferus	4	63	3,446	765				
Callinectes sapidus	1,718	1,388	11,835	15,448	4		218	
Dasyatis sabina			1	1				
Rhinoptera bonasus				1				
Acipenser oxyrhynchus	2							
Lepisosteus osseus	27		15	170	5		403	7
Amia calva	7			21	3		38	15
Elops saurus	7	8	92	43			5	
Anguilla rostrata	189	16	117	333	5		59	2
Myrophis punctatus			2					
Alosa aestivalis	22,405	900	195	279	1,099			
Alosa mediocris	22	1		9				
Alosa pseudoharengus	5,319	12	188	488	1,969		1,175	11
Alosa sapidissima	24	2		256				
Brevoortia tyrannus	18,004	1,787	42,812	280,940	4		65	
Dorosoma cepedianum	90	8	102	298	23		214	12
Dorosoma petenense	4		5	3				
Opisthonema oglinum	7	2	39	33				
Anchoa hepsetus	80	2,506	674	1,140				
Anchoa mitchilli	26,419	86,453	200,172	275,897	90		10	
Umbra pygmaea	4			1			1	
Esox a. americanus	25			23	5		2	8
Esox lucius					X[1]			
Esox niger	70			178	7		11	
Carassius auratus							1	
Cyprinus carpio	22		1	7			87	3
Hybognathus regius	773				2			
Notemigonus crysoleucas	1,038				257	5	86	75
Notropis analostanus					5			
Notropis chalybaeus				1				
Notropis cummingsae				25				
Notropis hudsonius	1,088			1				
Notropis procne	17							

Table 4. (continued)

Species	Sound				Lake			
	Albemarle Sound	Croatan Sound	N. Pamlico Sound	W. Pamlico Sound	Lake Phelps	New Lake	Lake Mattamuskeet	Pungo Lake
Erimyzon sucetta*	244			45	56			6
Moxostoma macrolepidotum	2							
Synodus foetens			30	45				
Ictalurus brunneus								1
Ictalurus catus	2,249	10	1	166	2		8	22
Ictalurus melas	1							
Ictalurus natalis	207	1		21	157		2	64
Ictalurus nebulosus	383	15	3	80	70		27	6
Ictalurus punctatus	220			112	33		35	130
Noturus gyrinus	238		1	10	72		10	26
Chologaster cornuta	1							
Aphredoderus sayanus	1,250			1,756	17		12	13
Opsanus tau		1	29	10				
Gobiesox strumosus	1	1	2	7				
Urophycis regia			17	2				
Ophidion marginatum			1					
Strongylura marina	372	262	4	57			26	
Cyprinodon variegatus				2			9	
Fundulus diaphanus	106	12	1	69	1		105	
Fundulus h. heteroclitus			6	25			21	
Fundulus majalis			6	8	2			
Fundulus waccamensis					6			
Lucania parva				400			10	
Gambusia affinis	43		21	64	22	1	390	88
Membras martinica	256	479	1	478				
Menidia beryllina	14,579	3,277	1,013	7,441			642	
Menidia menidia	197	1,206	62	86				
Syngnathus floridae			1					
Syngnathus fuscus	83	149	8	28				
Syngnathus louisianae				1				
Morone americana	25,430	40	314	972	654		1,891	10
Morone saxatilis	484	1	2	12	X[1]		84	
Centropristis striata	75			1				
Diplectrum formosum				13				
Acantharchus pomotis	12			7				
Centrarchus macropterus	174			171	8		1	61

Table 4. (continued)

	Sound				Lake			
Species	Albemarle Sound	Croatan Sound	N. Pamlico Sound	W. Pamlico Sound	Lake Phelps	New Lake	Lake Mattamuskeet	Pungo Lake
Enneacanthus chaetodon	85							
Enneacanthus gloriosus	209		3	518	18		24	4
Enneacanthus obesus	654		2	85	75		33	46
Lepomis auritus	50				1		1	
Lepomis cyanellus				1				
Lepomis gibbosus	733	26	28	1,137	283		114	6
Lepomis gulosus	301		3	121	49		46	18
Lepomis macrochirus	745	2	30	284	492		137	15
Lepomis marginatus				2				
Lepomis microlophus							42	
Micropterus salmoides	148		7	94	44		226	
Pomoxis annularis								1
Pomoxis nigromaculatus	614		1	90	11		26	21
Etheostoma fusiforme	743			89	24		3	3
Etheostoma olmstedi	94			1	13			
Etheostoma serriferum	27			34	1			
Perca flavescens	1,608	12	27	173	451		123	2
Pomatomous saltatrix	62	48	72	238				
Caranx hippos	26	9	162	155				
Chloroscombrus chrysurus				2				
Selene vomer		4	7	3				
Trachinotus falcatus	1	3	1					
Lutjanus analis			3					
Lutjanus griseus	1	6	83	3				
Lutjanus synagris			1					
Diapterus auratus	1	1	69	113				
Eucinostomus argenteus	2	3	7	34				
Eucinostomus gula	20	37	94	147				
Orthopristis chrysoptera	2	4	54	14				
Lagodon rhomboides	20	46	334	5,889			1	
Archosargus probatocephalus			31	34				
Bairdiella chrysoura	816	390	12,459	9,789			3	
Cynoscion nebulosus	8	26	527	432				
Cynoscion regalis	18	85	11,726	6,040				
Leiostomus xanthurus	5,867	1,775	75,506	331,675	11		128	
Menticirrhus americanus		5	10	1				

Table 4. (continued)

Species	Sound				Lake			
	Albemarle Sound	Croatan Sound	N. Pamlico Sound	W. Pamlico Sound	Lake Phelps	New Lake	Lake Mattamuskeet	Pungo Lake
Menticirrhus saxatilis		3	9	2				
Micropogonias undulatus	9,988	4,214	57,166	69,282	1			
Pogonias cromis			2	1				
Sciaenops ocellatus	33	21	71	100				
Stellifer lanceolatus		2						
Chaetodipterus faber			67	24				
Mugil cephalus	771	162	256	2,889			73	
Mugil curema		7						
Chasmodes bosquianus			3					
Hypleurochilus geminatus		1						
Hypsoblennius hentzi			2	2				
Gobionellus hastatus			17	8				
Gobiosoma bosci	9	7	112	766				
Microgobius thalassinus		3	478	1,315			14	
Trichiurus lepturus			3					
Scomberomorus maculatus			9	9				
Peprilus alepidotus	1	14	349	187				
Peprilus triacanthus		8	3	1				
Prionotus carolinus			1					
Prionotus evolans			4					
Prionotus tribulus			2					
Citharichthys spilopterus		4	126	61				
Paralichthys dentatus	18	34	120	42				
Paralichthys lethostigma	169	17	1,891	3,880			2	
Scophthalmus aquosus			1					
Trinectes maculatus	1,004	102	557	2,621			15	
Symphurus plagiusa		1	97	7				
Aluterus schoepfi		2						
Monocanthus hispidus		2		1				
Sphoeroides maculatus			1	2				

*All chubsuckers were reported as E. sucetta. It is likely that an unknown proportion were E. oblongus.

[1]Unsuccessful introduction attempt (Kornegay and Dineen 1979).

Table 5. Species' abundances as related to salinity. Data from many inland collections are not included because salinities were not recorded. Number of individuals are tabulated.

Species	Salinity Zone							Salinity Range
	Limnetic 0-0.5 °/oo	Oligohaline 0.5-5.0 °/oo	Lower Mesohaline 5.0-10.0 °/oo	Upper Mesohaline 10.0-18.0 °/oo	Lower Polyhaline 18.0-25.0 °/oo	Upper Polyhaline 25-30.0 °/oo	Euhaline 30 °/oo	(°/oo)
Penaeus aztecus	26	2,247	17,746	31,471	2,305	2		0-28.8
Penaeus duorarum	44	41	186	2,137	295	3		0-28.8
Penaeus setiferus	6	95	502	3,521	97			0-24.1
Callinectes sapidus	1,018	3,915	9,043	13,220	1,932	19		0-28.8
Dasyatis sabina				2				17.0-18.0
Acipenser oxyrhynchus	2							0.2- 0.3
Lepisosteus osseus	419	26	9	3				0-17.4
Amia calva	57	7	2					0- 9.9
Elops saurus	11	24	47	61	11			0-19.5
Anguilla rostrata	161	180	187	131	24			0-23.0
Alosa aestivalis	15,509	6,336	595	181	16			0-24.0
Alosa mediocris		21	2	5				1.8-14.0
Alosa pseudoharengus	7,376	1,144	307	76	50	1	1	0-30.2
Alosa sapidissima	12	7	3	253				0-18.0
Brevoortia tyrannus	47,447	30,628	85,369	102,168	47,673	27	24,500	0-30.2
Dorosoma cepedianum	327	110	77	69	10		11	0-30.2
Dorosoma petenense	4	1	1	4	2			0.2-21.0
Opisthonema oglinum	11	5	9	37	5			0-19.0
Anchoa hepsetus	97	1,034	1,863	1,191	128			0-22.0
Anchoa mitchilli	11,119	104,030	94,440	313,543	34,785	5,514	5,000	0-30.2
Umbra pygmaea		5	1					0.9- 5.5
Esox a. americanus	32	27	1					0- 9.9
Esox niger	56	70	63	74				0-16.3
Carassius auratus	1							0.0
Cyprinus carpio	110	5	2					0- 7.0
Hybognathus regius	106	645	1					0- 5.2
Notemigonus crysoleucas	810	1,062	12	1				0-11.8
Notropis analostanus	3	2						0- 0.9
Notropis chalybaeus	1							0.1
Notropis cummingsae	25							0.1
Notropis hudsonius	530	223	1					0- 5.4
Notropis procne	13	3						0- 1.2
Erimyzon sucetta*	217	131						0- 3.2

Table 5. (continued)

Species	Limnetic 0-0.5 ‰	Oligohaline 0.5-5.0 ‰	Lower Mesohaline 5.0-10.0 ‰	Upper Mesohaline 10.0-18.0 ‰	Lower Polyhaline 18.0-25.0 ‰	Upper Polyhaline 25-30.0 ‰	Euhaline 30 ‰	Salinity Range (‰)
Moxostoma macrolepidotum	2							0- 0.2
Synodus foetens			2	63	9			6.5-19.0
Ictalurus brunneus	1							0.0
Ictalurus catus	1,114	1,061	100	1				0-10.7
Ictalurus melas		1						3.2
Ictalurus natalis	91	346	6					0- 8.0
Ictalurus nebulosus	237	287	34	7				0-11.8
Ictalurus punctatus	356	159	10					0- 9.9
Noturus gyrinus	88	262	1					0- 7.2
Chologaster cornuta	1	1						0.1- 4.5
Aphredoderus sayanus	2,015	988	33					0- 8.7
Opsanus tau			12	23	3			6.0-24.1
Gobiesox strumosus		1	4	6				4.5-18.0
Urophycis regia			2	7				8.0-16.5
Ophidion marginatum				1				17.1
Strongylura marina	258	230	52	135	8	2		0-26.5
Cyprinodon variegatus	9	1		1				0-14.0
Fundulus diaphanus	171	84	19	14	1	1		0-26.5
Fundulus h. heteroclitus	21	1	13	17				0-16.3
Fundulus majalis	2	1	1	11				0-15.8
Fundulus waccamensis	6							0.0
Lucania parva	10	23	38	299				0-18.0
Gambusia affinis	528	50	8	39	3			0-23.9
Membras martinica	37	245	714	185				0-13.6
Menidia beryllina	6,592	10,835	5,619	1,851	132	37	21	0-30.2
Menidia menidia	158	594	289	401	18			0-19.0
Syngnathus floridae				1		1		16.0-26.5
Syngnathus fuscus	80	157	12	14	5			0-20.0
Syngnathus louisianae				1				12.0
Morone americana	21,874	4,752	927	247	58	8	16	0-30.2
Morone saxatilis	297	225	2	1				0-12.5
Centropristis striata		75		1				5-15.5
Diplectrum formosum			12	1				9.0-13.0
Acantharchus pomotis	8	11						0.1- 2.0

Table 5. (continued)

Species	Limnetic 0-0.5 °/oo	Olgohaline 0.5-5.0 °/oo	Lower Mesohaline 5.0-10.0 °/oo	Upper Mesohaline 10.0-18.0 °/oo	Lower Polyhaline 18.0-25.0 °/oo	Upper Polyhaline 25-30.0 °/oo	Euhaline 30 °/oo	Salinity Range (°/oo)
Centrarchus macropterus	96	222	77					0- 9.0
Enneacanthus chaetodon	85							0.2
Enneacanthus gloriosus	141	237	338	35	5			0-20.6
Enneacanthus obesus	311	548	25	8				0-16.3
Lepomis auritus	5	47						0- 4.8
Lepomis cyanellus	1							0.1
Lepomis gibbosus	468	721	608	498				0-18.0
Lepomis gulosus	154	363	15					0- 8.7
Lepomis macrochirus	782	763	79	8				0-15.8
Lepomis microlophus	42							0.0
Micropterus salmoides	292	139	65	15				0-16.3
Pomoxis annularis	1							
Pomoxis nigromaculatus	257	451	43					0- 8.7
Etheostoma fusiforme	89	762	7					0- 8.7
Etheostoma olmstedi	30	77						0- 4.8
Etheostoma serriferum	45	17						0.1- 0.9
Perca flavescens	1,283	770	225	30				0-16.3
Pomatomous saltatrix	6	122	113	122	18	2		0-26.5
Caranx hippos	10	30	99	147	23		30	0-30.2
Chloroscombrus chrysurus					2			20.0-21.0
Selene vomer			4	7	1			8.0-19.0
Trachinotus falcatus	1	3		1				0-16.0
Lutjanus analis				3				13.5-17.4
Lutjanus griseus		2	5	85	1			4.7-19.0
Lutjanus synagris				1				15.5
Diapterus auratus		4	10	162	1			1.2-20.0
Eucinostomus argenteus		2	12	29				1.4-15.5
Eucinostomus gula	16	4	54	206	9		7	0-30.2
Orthopristis chrysoptera	1	6	11	36	19			0-23.0
Lagodon rhomboides	12	82	1,861	3,992	209	1	6	0-30.2
Archosargus probatocephalus		3	34	19	7			4.1-19.2
Bairdiella chrysoura	17	801	1,704	14,948	2,805	15	7	0-30.2
Cynoscion nebulosus	3	37	104	720	48		7	0-30.2
Cynoscion regalis	1	144	1,193	9,248	6,775			0-24.1
Leiostomus xanthurus	3,328	53,046	145,845	179,409	18,189	361	48	0-30.2

Table 5. (continued)

	Salinity Zone							
Species	Limnetic 0-0.5 °/oo	Oligohaline 0.5-5.0 °/oo	Lower Mesohaline 5.0-10.0 °/oo	Upper Mesohaline 10.0-18.0 °/oo	Lower Polyhaline 18.0-25.0 °/oo	Upper Polyhaline 25-30.0 °/oo	Euhaline 30 °/oo	Salinity Range (°/oo)
Menticirrhus americanus		4	1	10				1.0-18.0
Menticirrhus saxatilis			3	10	1			5.8-22.0
Micropogonias undulatus	5,580	36,237	40,260	44,052	6,778	78	23	0-30.2
Pogonias cromis				2	1			11.0-18.8
Sciaenops ocellatus	9	26	44	121	9			0-20.0
Stellifer lanceolatus				2				11.7
Chaetodipterus faber			1	72	14			8.0-21.5
Mugil cephalus	592	1,441	867	497	88	1	16	0-30.2
Mugil curema		7						2.0
Chasmodes bosquianus				3				16.0
Hypsoblennius hentzi			1	2				7.0-17.7
Gobionellus hastatus			9	13	2			5.7-20.0
Gobiosoma bosci	4	90	373	378	41			0-23.9
Microgobius thalassinus	14	80	348	1,130	190	1		0-26.5
Trichiurus lepturus				3				11.5-17.0
Scomberomorus maculatus			1	11	3			9.8-21.0
Peprilus alepidotus		11	8	411	114			0.9-21.5
Peprilus triacanthus			1	11				8.0-18.0
Prionotus carolinus				1				15.0
Prionotus evolans				7	1			15.8-21.5
Prionotus tribulus				2				17.5-17.6
Citharichthys spilopterus		11	61	104	6			2.0-24.0
Paralichthys dentatus	8	34	26	106	28			0-24.1
Paralichthys lethostigma	90	553	2,138	2,738	219	3		0-28.0
Scophthalmus aquosus				1				15.0
Trinectes maculatus	416	954	1,158	1,293	99			0-24.1
Symphurus plagiusa		1	15	69	16			5.0-23.0
Aluterus schoepfi				1	1			17.0-19.5
Monocanthus hispidus				3				10.2-15.0
Sphoeroides maculatus		1	1	1				1.5-15.5

*All chubsuckers were reported as E. sucetta. It is likely that an unknown proportion were E. oblongus.

1980) or a relict population (Bailey 1977). These stenohaline primary freshwater fishes were generally restricted to Albemarle Sound, the Pungo River or the inland lakes.

A large proportion of the species encountered were transient, primary freshwater fish. These species commonly entered low salinity waters, but were rarely found at salinities greater than $18^{\circ}/_{\circ\circ}$. Most were captured in Albemarle Sound, Pungo River or the inland lakes. Carassius auratus and Cyprinus carpio are introduced species (Lee et al. 1980). Although generally more recreationally than commercially important, the group had a dockside value of $235,705 (N.C. Division of Mar. Fish. 1984) in North Carolina's 1983 commercial landings.

Many nekton species are indigenous to the estuary, generally completing their life cycle within the lower salinity waters of the estuary. They are considered residents even though they are commonly found in the coastal ocean environment. These species have a tolerance to a wide range of salinities and are often distributed ubiquitously. They are important prey items for many species utilizing the estuary (Darnell 1958; Carr and Adams 1973; Overstreet and Heard 1982). Most resident species are abundant and, except for blue crabs and white perch, they are not commercially important. Estuarine residents, including sessile shellfish species, had a 1983 dockside value of $15,876,665 in North Carolina's commercial landings (N.C. Div. of Mar. Fish. 1984).

Anadromous fish spend most of their life at sea, but adults migrate to freshwater during spring spawning runs. Offspring utilize the low salinity waters as nurseries, and most species usually emigrate during their first fall. Striped bass are generally considered an anadromous species which remains in the estuary until reaching sexual maturity. However, populations in Albemarle Sound may complete their entire life cycle within the estuary (Street and Pate 1975). Adults of all anadromous species are commercially and recreationally important, and in 1983 were worth $1,170,419 to North Carolina's commercial fishermen (N.C. Div. of Mar. Fish. 1984)

The American eel is catadromous, spending most of its life in fresh or brackish waters. Upon reaching sexual maturity it migrates to the Sargasso Sea to spawn. Pelagic leptocephali are carried inshore and after transforming into elvers migrate into the estuaries, where they

Table 6. Life history strategies of nekton collected on the Pamlico-Albemarle Peninsula. Number of individuals captured are indicated for each species.

Species	Freshwater	Freshwater transient	Estuarine indigenous	Anadromous	Catadromous	Migratory marine	Marine transient
Penaeus aztecus						54,933	
Penaeus duorarum						3,125	
Penaeus setiferus						4,278	
Callinectes sapidus			30,611				
Dasyatis sabina							2
Rhinoptera bonasus							1
Acipenser oxyrhynchus				2			
Lepisosteus osseus		627					
Amia calva		84					
Elops saurus						155	
Anguilla rostrata					721		
Myrophis punctatus							2
Alosa aestivalis				24,878			
Alosa mediocris				32			
Alosa pseudoharengus				9,152			
Alosa sapidissima				282			
Brevoortia tyrannus						343,612	
Dorosoma cepedianum		747					
Dorosoma petenense		12					
Opisthonema oglinum							81
Anchoa hepsetus			4,400				
Anchoa mitchilli			589,041				
Umbra pygmaea		6					
Esox a. americanus		63					
Esox niger		266					
Carassius auratus		1					
Cyprinus carpio		120					
Hybognathus regius		775					
Notemigonus crysoleucas		1,933					
Notropis analostanus		5					
Notropis chalybaeus	1						
Notropis cummingsae	25						
Notropis hudsonius		1,089					
Notropis procne	17						
Erimyzon sucetta*		351					
Moxostoma macrolepidotum	2						

Table 6. (continued)

Species	Freshwater	Freshwater transient	Estuarine indigenous	Anadromous	Catadromous	Migratory marine	Marine transient
Synodus foetens							75
Ictalurus brunneus	1						
Ictalurus catus		2,458					
Ictalurus melas	1						
Ictalurus natalis		452					
Ictalurus nebulosus		584					
Ictalurus punctatus		530					
Noturus gyrinus		357					
Chologaster cornuta	2						
Aphredoderus sayanus		3,048					
Opsanus tau							40
Gobiesox strumosus			11				
Urophycis regia							19
Ophidion marginatum							1
Strongylura marina			721				
Cyprinodon variegatus			11				
Fundulus diaphanus			294				
Fundulus h. heteroclitus			52				
Fundulus majalis			16				
Fundulus waccamensis	6						
Lucania parva			410				
Gambusia affinis			629				
Membras martinica			1,214				
Menidia beryllina			26,952				
Menidia menidia			1,551				
Syngnathus floridae			2				
Syngnathus fuscus			268				
Syngnathus louisianae			1				
Morone americana			29,311				
Morone saxatilis				583			
Centropristis striata							76
Diplectrum formosum							13
Acantharchus pomotis		19					
Centrarchus macropterus		415					
Enneacanthus chaetodon	85						
Enneacanthus gloriosus		776					
Enneacanthus obesus		895					

Table 6. (continued)

Species	Freshwater	Freshwater transient	Estuarine indigenous	Anadromous	Catadromous	Migratory marine	Marine transient
Lepomis auritus		52					
Lepomis cyanellus	1						
Lepomis gibbosus		2,327					
Lepomis gulosus		538					
Lepomis macrochirus		1,705					
Lepomis marginatus	2						
Lepomis microlophus	42						
Micropterus salmoides		519					
Pomoxis annularis	1						
Pomoxis nigromaculatus		763					
Etheostoma fusiforme		862					
Etheostoma olmstedi		108					
Etheostoma serriferum		62					
Perca flavescens		2,396					
Pomatomous saltatrix							420
Caranx hippos						352	
Chloroscombrus chrysurus						2	
Selene vomer							14
Trachinotus falcatus							5
Lutjanus analis							3
Lutjanus griseus							93
Lutjanus synagris							1
Diapterus auratus			184				
Eucinostomus argenteus			46				
Eucinostomus gula			298				
Orthopristis chrysoptera						74	
Lagodon rhomboides						6,320	
Archosargus probatocephalus							65
Bairdiella chrysoura						23,457	
Cynoscion nebulosus						993	
Cynoscion regalis						17,869	
Leiostomus xanthurus						414,962	
Menticirrhus americanus							16
Menticirrhus saxatilis							14
Micropogonias undulatus						140,651	
Pogonias cromis						3	
Sciaenops ocellatus						225	

Table 6. (continued)

Species	Freshwater	Freshwater transient	Estuarine indigenous	Anadromous	Catadromous	Migratory marine	Marine transient
Stellifer lanceolatus							2
Chaetodipterus faber							91
Mugil cephalus						4,151	
Mugil curema							7
Chasmodes bosquianus			3				
Hypleurochilus geminatus							1
Hypsoblennius hentzi			4				
Gobionellus hastatus			25				
Gobiosoma bosci			894				
Microgobius thalassinus			1,810				
Trichiurus lepturus							3
Scomberomorus maculatus							18
Peprilus alepidotus							551
Peprilus triacanthus							12
Prionotus carolinus							1
Prionotus evolans							8
Prionotus tribulus							2
Citharichthys spilopterus							191
Paralichthys dentatus						214	
Paralichthys lethostigma						5,959	
Scophthalmus aquosus							1
Trinectes maculatus			4,299				
Symphurus plagiusa							105
Aluterus schoepfi							2
Monocanthus hispidus							3
Sphoeroides maculatus							3

*All chubsuckers were reported as E. sucetta. It is likely that an unknown proportion were E. oblongus.

may remain for 7 to 20 years (Hardy 1978a). North Carolina's 1983 dockside value of American eels was $270,708 (N.C. Div. Mar. Fish. 1984).

The majority of individuals collected on the peninsula represented the migratory marine life history strategy; estuarine nursery areas are requisite for the early life history stages of this group. Most species spawn at sea during the winter when onshore transport is maximal (Miller et al. in press); however, several species such as those of the genus Cynoscion are spring and summer spawners in the nearshore or estuarine environment. Juveniles of all migratory marine species utilize the estuarine nurseries and as young-of-the-year migrate to higher salinity areas. This species group accounts for over 50% of the value of North Carolina's commercial landings and is also an important species group for recreational fisheries. In 1983 its commercial dockside value was $33,873,102 (N.C. Div. Mar. Fish. 1984).

A large number of marine transient species were collected on the peninsula. These species were not common and were usually taken in the higher salinity areas. They have little or no direct dependence on the estuary but may be abundant seasonally in the open waters of North Carolina's large sounds (Higgins and Pearson 1928; Schwartz 1973; DeVries 1980).

Profiles of the Most Common Species

Three gears, the seine, the 3.2 m (10.5 ft) flat trawl and the wing trawl, were employed concurrently for several years and had broad geographic coverage. Species' CPUE were calculated for each of these gears and expressed as catch-per-effort based on the normal effort expended by a gear at a single station (seine - 1 haul; wing trawl - 10 min.; flat trawl - 1 min.). Only trawl data from bottom tows and from collections of a known duration were used in the calculations. Total effort for each gear and area is given in Table 7. Twenty species averaged greater than one individual per effort in one of the three gears (Table 8) and are discussed in detail in the following pages. Recruitment, as used in the discussion of these commonly occurring species, refers to recruitment to the various gears.

Table 7. Seine, wing trawl and flat trawl (3.2 m) sampling effort in each area of the Pamlico-Albemarle Peninsula.

Area	Gear		
	Seine (hauls)	Wing trawl (minutes)	Flat trawl (minutes)
Albemarle Sound	224	3,074.5	
Mackeys Creek			
Scuppernong River	130	925.0	
Alligator River			
north of hwy 64 bridge	15	377.0	
hwy 64 bridge to Frying Pan Straits/Stumpy Pt.		350.0	
Frying Pan Straits/Stumpy Pt. to Newport News Pt./Marker R"10"		350.0	
Newport News Pt./Marker R"10" to the Northwest Fork	720.0		
above the Northwest Fork			
Northwest Fork			
Croatan Sound	115	735.0	17.0
Pamlico Sound			
north of Bluff Shoal			
Stumpy Point Bay			247.0
Parched Corn Bay, Long Shoal River,	1		480.3
Otter creak			287.3
Far Cr. Middletown Anchorage, Brooks Creek			287.3
Wysocking Bay	3		308.0
Outfall Canal, East Bluff Bay			148.8
west of Bluff Shoal			
West Bluff Bay, Cunning Harbor, Juniper Bay			289.5
Swanquarter Bay			817.5
Deep Cove, White Perch Bay			122.0
Rose Bay			1,204.3
Spencer Bay			447.5
Abel Bay, Crooked Creek			142.5
Pungo River			
below Field Point/Sandy Point	40		263.0
Field Point/Sandy Point to Durants Point/Windmill Pt.	11		193.8
Pantego Creek, Pungo Creek	43	26.0	259.5
Durants Pt./Windmill Pt. to hwy 264 bridge	40	10.0	174.0
above hwy 264 bridge	5	1.0	63.0
Inland Lakes			
Lake Phelps	1,140.0		
New Lake			
Lake Mattamuskeet	35		
Pungo Lake	1		

Table 8. Seine, flat trawl and wing trawl catch-per-unit effort for species collected on the Pamlico-Albemarle Peninsula. Only bottom towed trawl data are used in calculating trawl CPUE. Rank indicates the relative position of a species based on its CPUE with the particular gear.

	Seine		3.2 m flat trawl		7.9 m wing trawl	
Species	Rank	CPUE	Rank	CPUE	Rank	CPUE*10
Penaeus aztecus	25	0.14	5	7.86	27	0.05
Penaeus duorarum	53	0.01	13	0.44		
Penaeus setiferus	36	0.04	11	0.73	62	*
Callinectes sapidus	18	0.54	6	3.46	10	0.81
Dasyatis sabina			75	*		
Acipenser oxyrhynchus					54	*
Lepisosteus osseus	65	*	56	*	37	0.01
Amia calva					61	*
Elops saurus	42	0.02	35	0.02		
Anguilla rostrata	33	0.05	21	0.06	24	0.08
Myrophis punctatus			83	*		
Alosa aestivalis	4	17.51	24	0.06	3	10.76
Alosa mediocris	40	0.03	61	*	43	0.01
Alosa pseudoharengus	13	1.50	22	0.06	6	4.91
Alosa sapidissima	41	0.03	25	0.05	53	*
Brevoortia tyrranus	3	35.20	4	8.26	9	0.83
Dorosoma cepedianum					25	0.06
Dorosoma petenese	32	0.07	60	*	45	*
Opisthonema oglinum	61	*	44	0.01	52	*
Anchoa hepsetus	9	3.71	20	0.08	11	0.80
Anchoa mitchilli	1	131.49	1	64.12	1	36.69
Esox a. americanus	72	*				
Esox niger					40	0.01
Cyprinus carpio			74	*	30	0.02
Hybognathus regius	16	0.98			28	0.03
Notemigonus crysoleucas	35	0.05			35	0.01
Notropis hudsonius	14	1.36	93	*	15	0.30
Notropis procne	54	0.01				
Moxostoma macrolepidotum					51	*
Synodus foetens			52	0.01		
Ictalurus catus	44	0.02	36	0.02	7	2.06

Table 8 (continued)

	Seine		3.2 m flat trawl		7.9 m wing trawl	
	Rank	CPUE	Rank	CPUE	Rank	CPUE*10
Ictalurus melas					60	*
Ictalurus natalis			82	*	42	0.01
Ictalurus nebulosus			49	0.01	14	0.36
Ictalurus punctatus	60	*			19	0.18
Noturus gyrinus					44	*
Aphredoderus sayanus					17	0.19
Opsanus tau			55	*		
Gobiesox strumosus	59	*	73	*		
Strongylura marina	15	1.04	92	*		
Cyprinodon variegatus			81	*		
Fundulus diaphanus	24	0.17	48	0.01	59	*
Fundulus h. heteroclitus	71	*	62	*		
Fundulus majalis	64	*	64	*		
Fundulus waccamensis					41	0.01
Lucania parva	70	*	23	0.06		
Gambusia affinis	26	0.12	91	*		
Membras martinica	11	1.92	68	*		
Menidia beryllina	2	38.59	19	0.10	22	0.13
Menidia menidia	10	2.37	42	0.01		
Syngnathus fuscus	19	0.38	54	*		
Syngnathus louisianae			90	*		
Morone americana	7	4.98	17	0.16	2	22.51
Morone saxatilis	20	0.33	67	*	16	0.29
Centropristis striata	27	0.12				
Diplectrum formosum			57	*		
Centrarchus macropterus	45	0.02	34	0.02		
Enneacanthus gloriosus	52	0.01	39	0.01		
Enneacanthus obesus	58	*				
Lepomis auritus	39	0.03			58	*
Lepomis gibbosus	21	0.21	26	0.04	18	0.19
Lepomis gulosus			63	*	36	0.01
Lepomis macrochirus	22	0.20	37	0.	12	0.59

Table 8 (continued)

Species	Seine		3.2 m flat trawl		7.9 m wing trawl	
	Rank	CPUE	Rank	CPUE	Rank	CPUE*10
Micropterus salmoides	28	0.11	80	*	50	*
Pomoxis nigromaculatus	69	*	66	*	13	0.58
Etheostoma olmstedi	57	*			39	0.01
Perca flavescens	17	0.77	41	0.01	8	0.84
Pomatomous saltatrix	23	0.18	28	0.04	32	0.02
Caranx hippos	34	0.05	31	0.03	34	0.01
Selene vomer	63	*	71	*	57	*
Trachinotus falcatus	56	*	88	*		
Lutjanus analis			79	*		
Lutjanus griseus	49	0.01	38	0.02		
Lutjanus synagris			87	*		
Diapterus auratus	67		29	0.03	55	*
Eucinostomus argenteus	68	*	46	0.01	56	*
Eucinostomus gula	31	0.09	27	0.04	47	*
Orthopristis chrysoptera	50	0.01	47	0.01		
Lagodon rhomboides	29	0.10	9	1.05	26	0.05
Archosargus probatocephalus			45	0.01		
Bairdiella chrysoura	12	1.82	7	2.66	20	0.14
Cynoscion nebulosus	37	0.04	16	0.16	46	*
Cynoscion regalis	38	0.03	8	1.64	23	0.11
Leiostomus xanthurus	5	14.32	2	53.66	5	5.99
Menticirrhus americanus	51	0.01	58	*		
Menticirrhus saxatilis	55	*	59	*		
Micropogonias undulatus	6	8.27	3	13.58	4	7.64
Pogonias cromis			78	*		
Sciaenops ocellatus	30	0.09	30	0.03		
Stellifer lanceolatus					49	*
Chaetodipterus faber			51	0.01		
Mugil cephalus	8	4.24	15	0.17		
Mugil curema	48	0.01				
Chasmodes bosquianus			69	*		
Hypleurochilus geminatus			86	*		

Table 8 (continued)

Species	Seine		3.2 m flat trawl		7.9 m wing trawl	
	Rank	CPUE	Rank	CPUE	Rank	CPUE*10
Hypsoblennius hentzi			70	*		
Gobionellus hastatus			53	*		
Gobiosoma bosci	62	*	18	0.14		
Microgobius thalassinus			14	0.30		
Trichiurus lepturus			85	*		
Scomberomorus maculatus			65	*		
Peprilus alepidotus			32	0.03	38	0.02
Peprilus triacanthus					38	0.01
Prionotus carolinus			89	*		
Prionotus evolans			72	*		
Citharichthys spilopterus	66	*	33	0.02		
Paralichthys dentatus	46	0.01	40	0.01	33	0.01
Paralichthys lethostigma	47	0.01	10	0.92	29	0.02
Scophthalmus aquosus			84	*		
Trinectes maculatus	43	0.02	12	0.44	21	0.14
Symphurus plagiusa			43	0.01		
Aluterus schoepfi			77	*		
Monocanthus hispidus					48	*
Sphoeroides maculatus			76	*		

*less than 0.01 individual per effort.

Penaeus aztecus

Brown shrimp have an annual life cycle, spawning at sea in late winter (Perez Farfante 1969). Larvae are carried by onshore currents into estuarine nursery areas where as postlarvae, they occur most often on loose, fine grained substrates, typical of the upper estuary nursery areas (Williams 1958). Juveniles are first found in April (Figure 4) (Williams 1955) and continue recruiting into the summer, reaching peak abundance in June (Figure 5). Upon attaining maturity in mid to late summer, brown shrimp migrate toward the nearest inlet (McCoy 1968). Wing trawl and seine catches of brown shrimp were negligible (Figure 6). Most were taken in the mesohaline waters of Pamlico Sound by the 3.2 m (10.5 ft) flat trawl. Although monthly CPUE of brown shrimp appears higher in northern Pamlico Sound than in western Pamlico Sound (Figure 5), the latter area includes the Pungo River area which is usually not a productive brown shrimp nursery area, probably due to its lower salinities (J. H. Hawkins pers. comm.). When the Pungo River area is excluded, the CPUE at stations in the northern and western basins were similar (Figure 6).

Shrimp are a valuable resource to the peninsula (Appendix A) and are taken predominately in shrimp trawls[1]. The annularity of the brown shrimp crop is reflected by the yearly fluctuations in North Carolina's commercial landings. On the average brown shrimp comprise nearly 70% of the state's shrimp landings and most are taken in Pamlico Sound (N.C. Div. Mar. Fish. 1983). Pamlico Sound and tributary spring catches of *P. aztecus* in the DMF juvenile stock assessment program are highly correlated with brown shrimp landings in Pamlico and Core Sounds (DeVries 1984).

Callinectes sapidus

The spawning season of blue crabs is quite long, extending from mid-March through October in North Carolina (Williams 1984). After mating in low salinity waters, females migrate into the high salinity waters near the inlets where the eggs hatch and zoeae develop. Once near the sea, the mature females tend to remain there whereas males remain in the low salinity areas of the estuary (Williams 1984; Fischler 1965). After transforming to the megalops stage, the young crabs

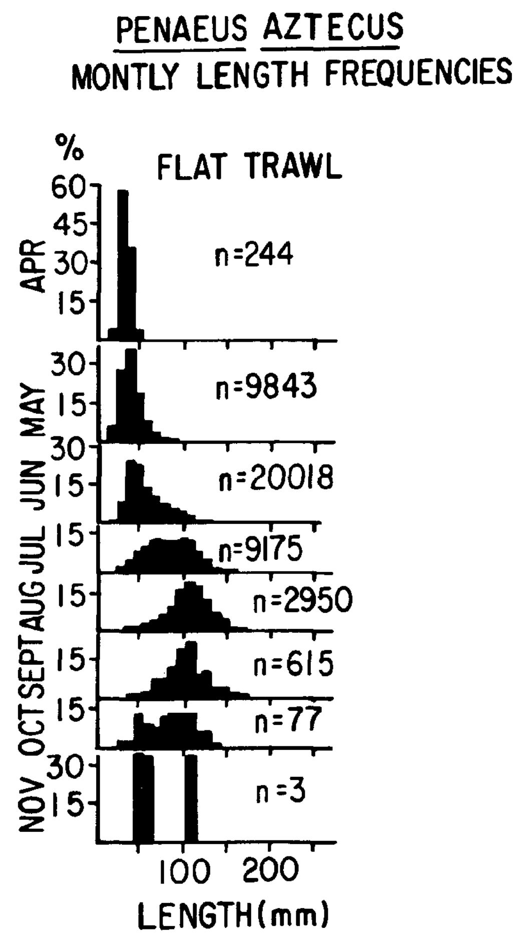

Figure 4. Monthly length frequencies of Penaeus aztecus.

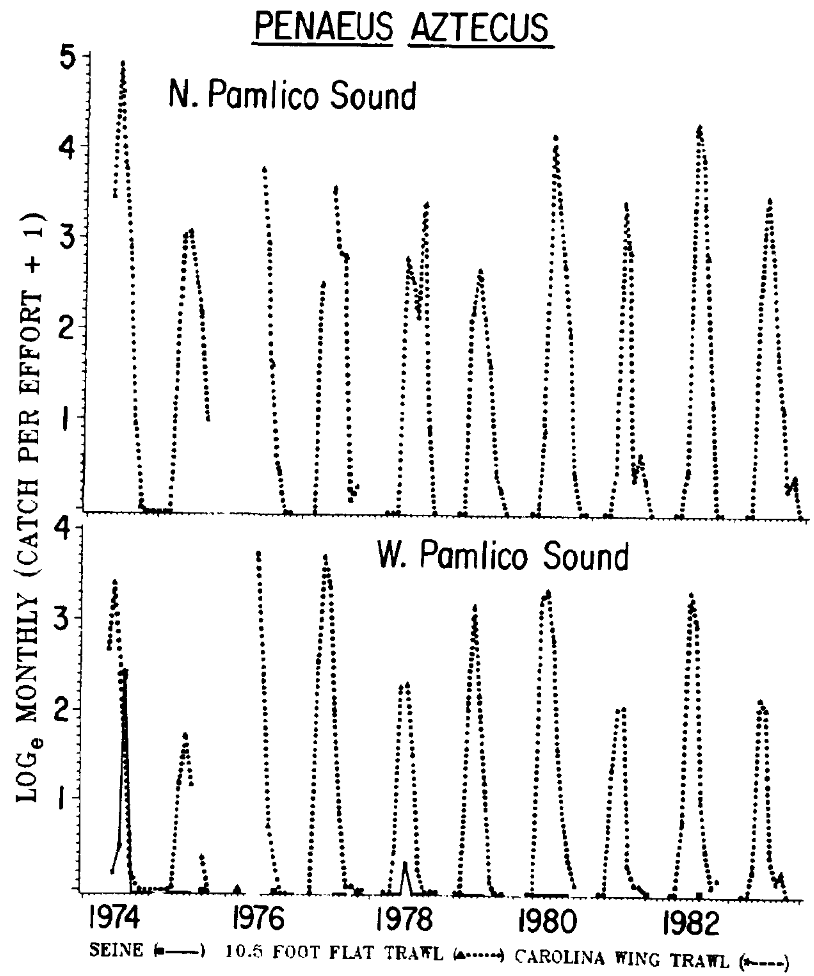

Figure 5. Penaeus aztecus monthly catch per effort.

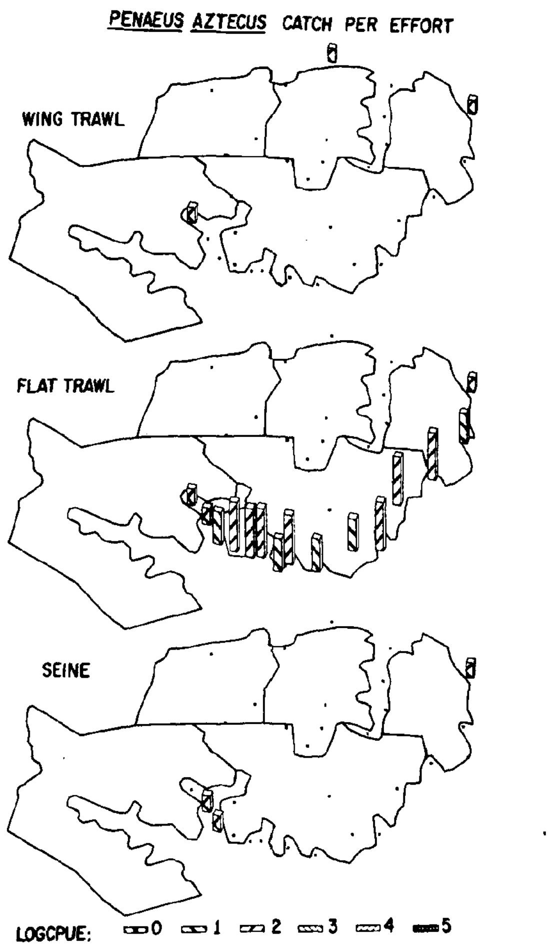

Figure 6. Geographical distribution of <u>Penaeus aztecus</u> catches.

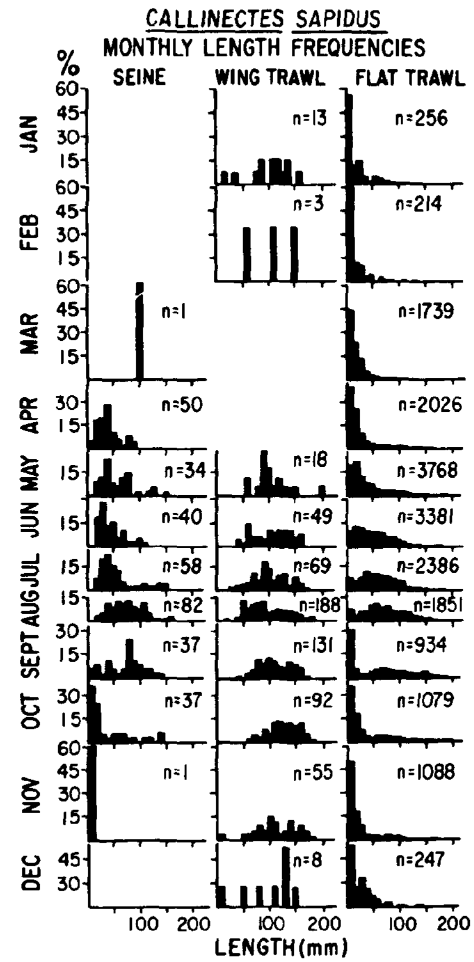

Figure 7. Monthly length frequencies of <u>Callinectes</u> <u>sapidus</u>.

migrate up the estuary, undergoing an estimated 18 to 20 more molts in less than 1½ years before reaching maturity (Williams 1965).

Despite the protracted spawning season, recruitment into the estuarine nursery areas is lowest during the summer months and highest in the spring (Figure 7) (Ross and Epperly in press). Blue crabs were present throughout the year in the low salinity waters of the peninsula, but were most abundant in the spring recruitment months, particularly at Pamlico Sound flat trawl stations (Figure 8). Catches in Pamlico Sound stations north of Bluff Shoal were consistently higher than catches at stations west of the shoal (Figure 9).

Blue crabs are taken commercially in pots, trawls, dredges and on trot lines and rank second to menhaden in volume landed in North Carolina.[1] North Carolina commercial landings (Street 1984) and peninsula landings (Appendix A) peaked in 1981 and 1982 coincident with peak catches of blue crabs in the DMF juvenile stock assessment program conducted on the peninsula (Figure 8). Most landings are taken from Pamlico Sound but the Albemarle Sound fishery has been expanding (Street 1984).

Alosa aestivalis

The blueback herring is an anadromous species spending most of its life at sea. In the early spring, they migrate to freshwater to spawn, arriving later than the alewife on the spawning grounds (Street and Pate 1975; Marshall 1976; Johnson et al. 1977; Johnson et al. 1981; Winslow and Sanderlin 1983). Juveniles begin recruiting to the various sampling gears in early summer (Figure 10), utilizing the freshwater and low salinity areas as nurseries but move seaward with increasing age. Most emigrate by late fall, but as evidenced by the length frequency histograms (Figure 10), some overwinter within the estuary.

Commercial landings of river herring from northern Pamlico Sound and the Tar-Pamlico are insignificant relative to the Albemarle Sound landings (Marshall 1976; Winslow and Sanderlin 1983). The disproportionate population sizes are also reflected in the juvenile catches in the two areas. Juvenile blueback herring catches outside of the Albemarle Sound area were low and inconsistent (Figure 11). The rare occurrences of blueback herring in the flat trawl catches of

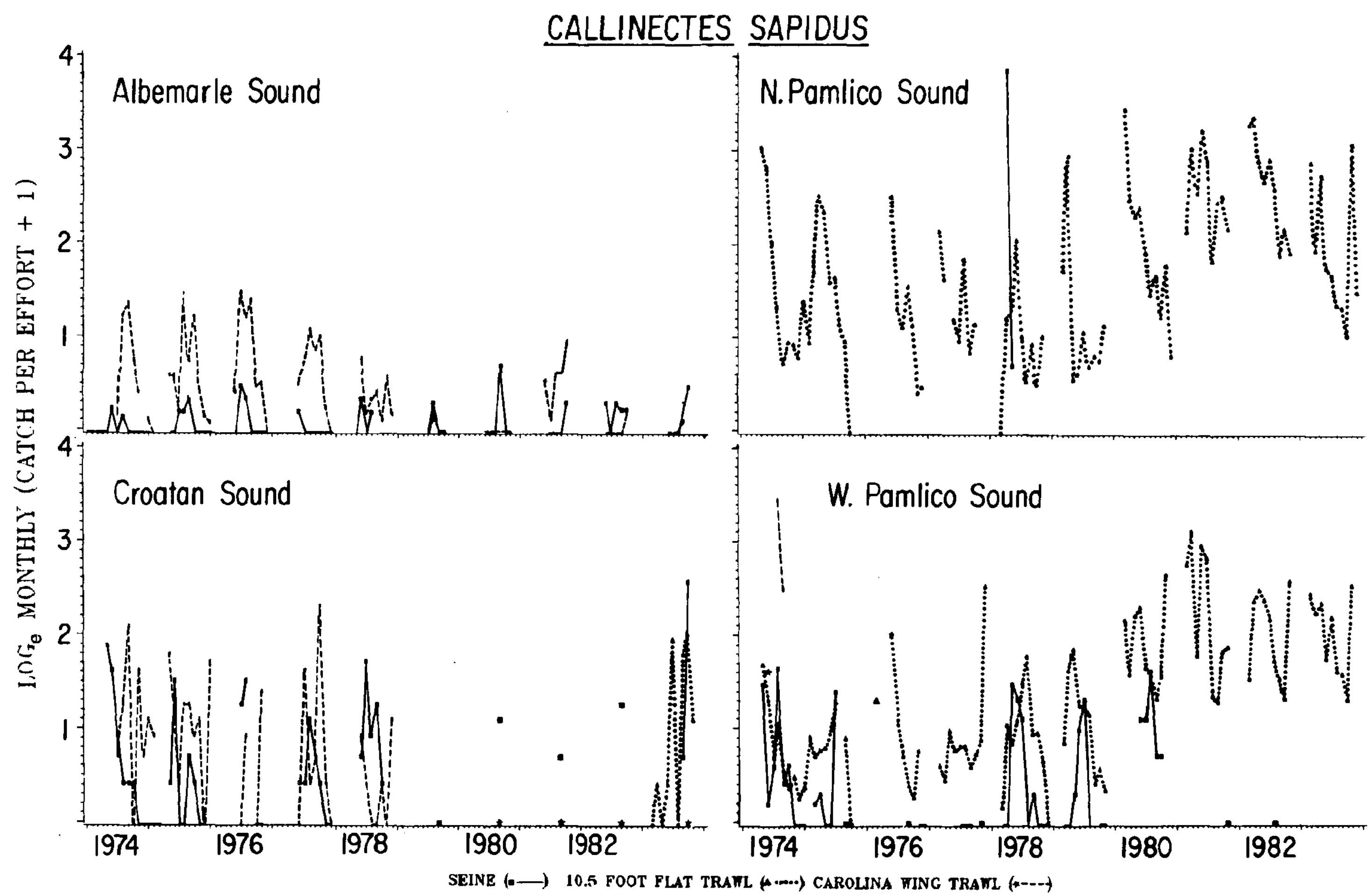

Figure 8. <u>Callinectes</u> <u>sapidus</u> monthly catch per effort.

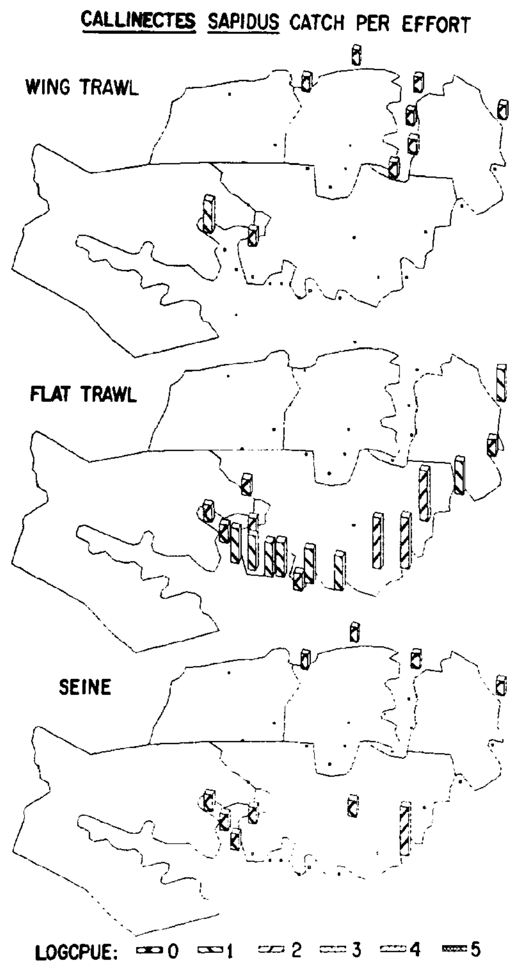

Figure 9. Geographical distribution of Callinectes sapidus catches.

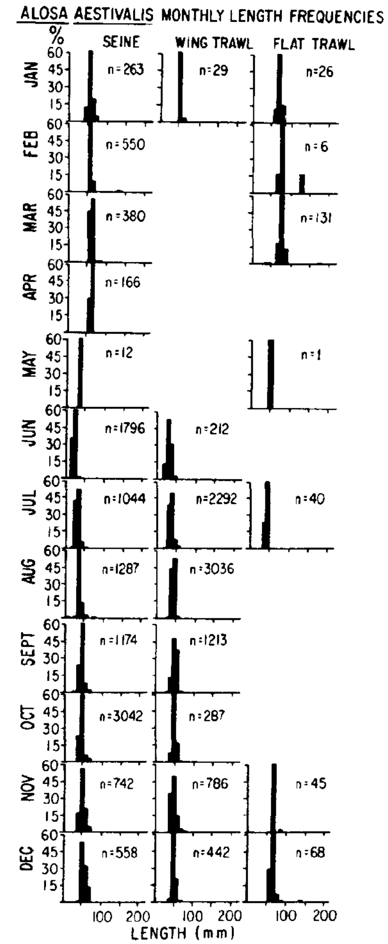

Figure 10. Monthly length frequencies of Alosa aestivalis.

Pamlico Sound were exclusively overwintering young-of-the-year. Seine catches were generally higher than wing trawl catches; both were generally bimodal within a year (Figure 12) and were highest in Albemarle Sound proper, particularly in the fall. The first peak in abundance occurred in the early summer and was predominately new recruits. The second, fall peak probably represents the emigration of individuals from the western Albemarle Sound tributaries. The 1981 juvenile catch was extremely low relative to other years and may be attributed to drought conditions which allowed farther than normal penetration of saline waters, causing juveniles to occupy nursery areas farther upstream than those included in the regular sampling program (Winslow and Sanderlin 1983).

Alosa pseudoharengus

The alewife is an anadromous species generally ascending freshwater earlier in the spring than the blueback herring (Tyus 1971; Street and Pate 1975; Marshall 1976; Johnson et al. 1977; Johnson et al. 1981; Winslow and Sanderlin 1983). Offspring utilize the upper estuary as nurseries and begin recruiting in June (Figure 13). They emigrate by late fall but some overwintering occurs. Juvenile survey catches outside the Albemarle Sound area were insignificant; the majority of alewives taken in the flat trawl catches of Pamlico Sound were collected in the early summer and were young-of-the-year (Figure 14). Catches in Albemarle Sound were inconsistent as to which gear (the seine or the wing trawl) produced higher catches but were generally bimodal within a year reflecting the summer recruitment period and the fall emigration of alewives from western Albemarle Sound tributaries (Figure 15). Overall catches were highest in the seine collections in Albemarle Sound proper and were lower in 1981-1983 than in previous years. Alewives were not as abundant as blueback herring.

Brevoortia tyrannus

Atlantic menhaden is a coastal, pelagic, schooling species which in the South Atlantic Bight spawns at sea throughout the winter (Higham and Nicholson 1964). Offspring migrate into the low salinity estuarine waters, recruiting as early as February (Figure 16) and reach peak

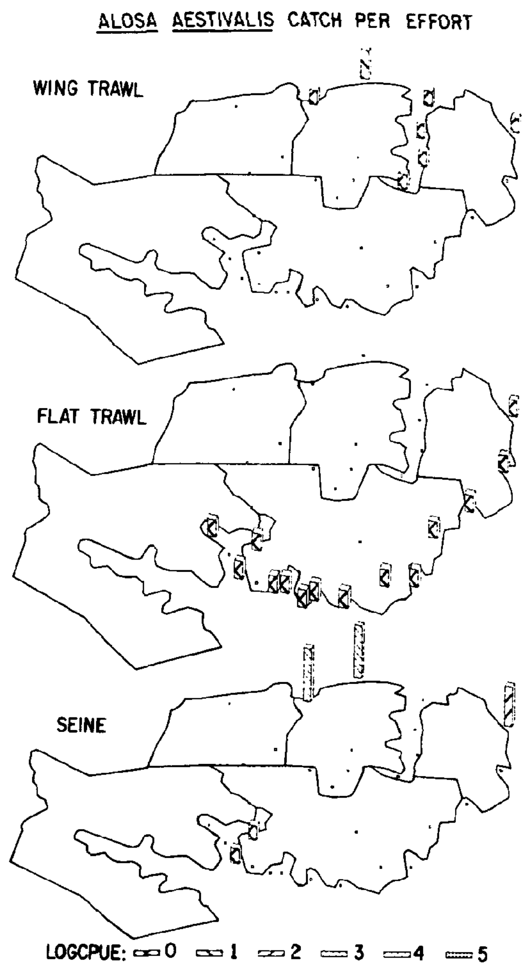

Figure 11.
Geographical distribution of Alosa aestivalis catches.

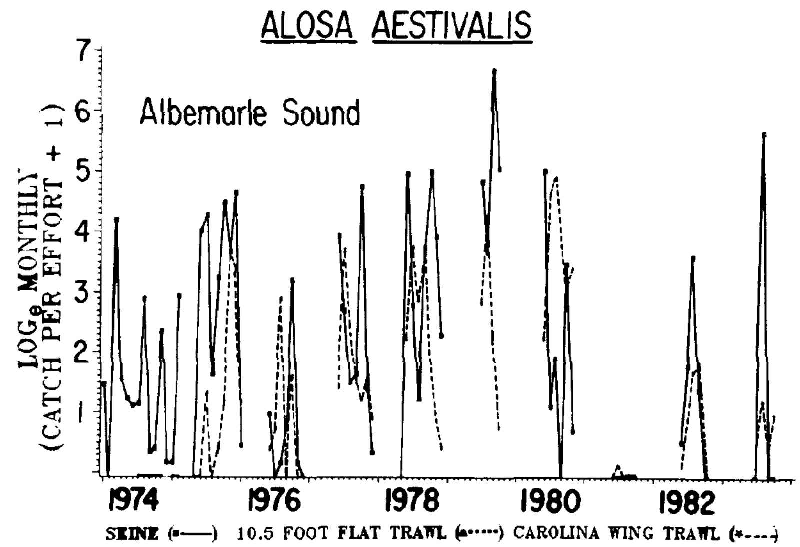

Figure 12.
Alosa aestivalis monthly catch per effort.

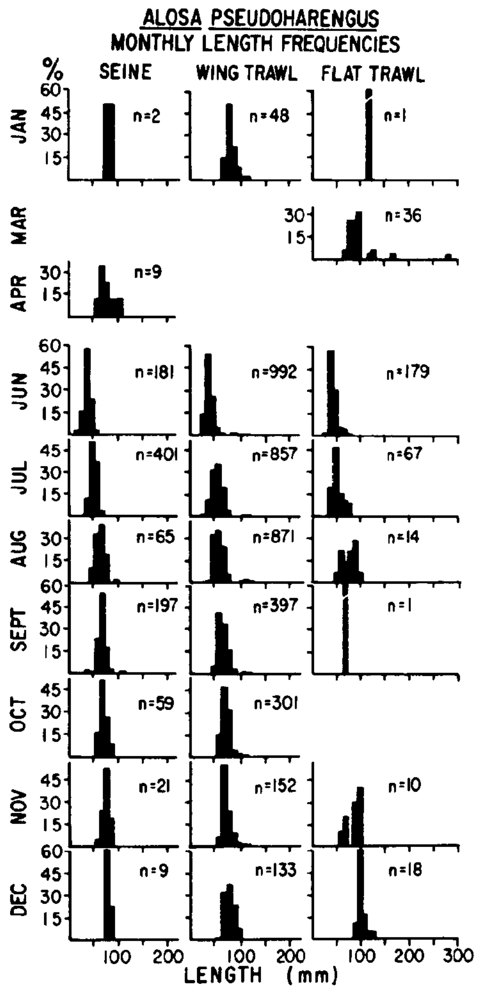

Figure 13. Monthly length frequencies of Alosa pseudoharengus.

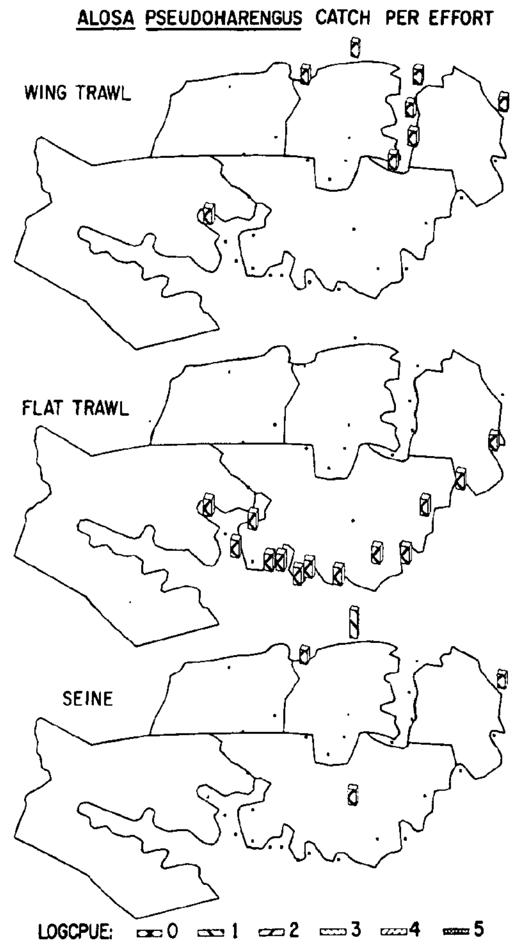

Figure 14. Geographical distribution of Alosa pseudoharengus catches.

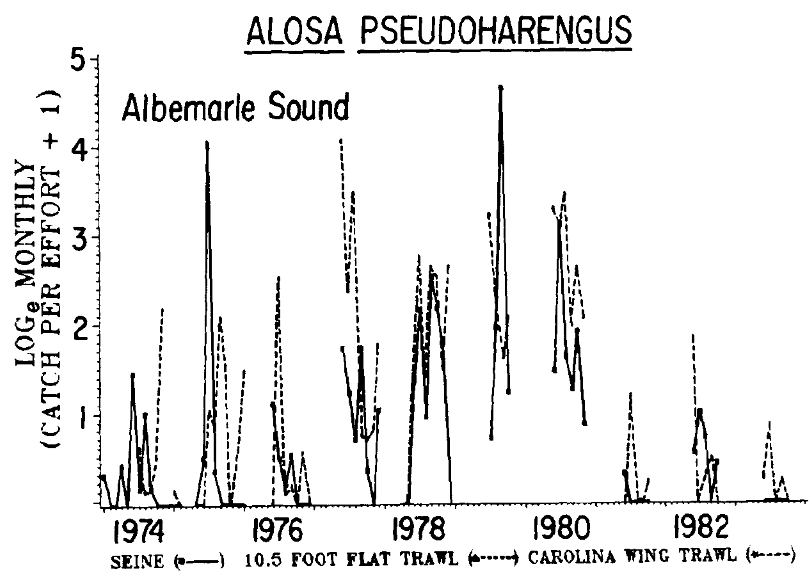

Figure 15.
Alosa pseudoharengus monthly catch per effort.

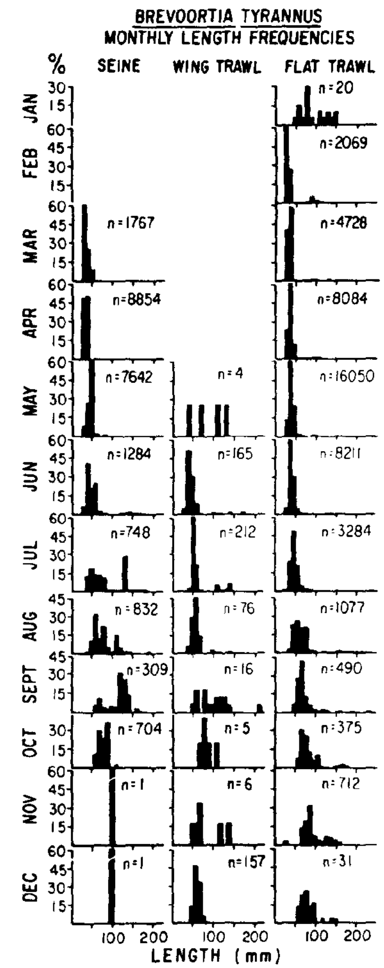

Figure 16. Monthly length frequencies of Brevoortia tyrannus.

abundance in late spring (Figure 17). Juveniles move downstream with increasing size and most emigrate by late fall.

The species is ubiquitously distributed throughout the peninsula (Figure 18) and may be present year round. It is one of the most abundant species collected on the peninsula and in the state (Carpenter 1979; Carpenter and Ross 1979; Ross 1980a; Ross and Carpenter 1983; Hawkins 1982; Ross and Epperly in press). Because bottom trawls do not efficiently sample pelagic, schooling species, seine catches were consistently higher but quite variable in all areas.

The combined commercial fisheries for Atlantic and Gulf menhaden comprise the largest fishery, by volume, in the United States. The meal and condensed solubles are rich in proteins and are used for poultry and livestock food supplements. The oil is used in various industrial products including paints, soaps, and lubricants. There are no reduction plants on the peninsula. Atlantic menhaden are very abundant in the open waters of Pamlico and Core sounds and the menhaden industry often deploy their purse seines in the inshore waters. It is also one of the most common species taken in the long haul seine and pound net fisheries (DeVries 1980; Ross 1982) and is an important source of bait for the state's crab pot fishery.

Anchoa hepsetus

Striped anchovies form large schools in nearshore and estuarine pelagic environments. Spawning occurs in late spring and early summer (Jones et al. 1978) but recruitment on the peninsula was not well defined. Catches with all gears were relatively low, inconsistent and insignificant in all areas except in Croatan Sound and the mouth of the Pungo River where seine catches were sporadically high (Figure 19).

Anchoa mitchilli

The bay anchovy is an abundant schooling estuarine resident which spawns in shallow water in the spring and summer (Jones et al. 1978). Juveniles are recruited first in June in the seine and flat trawl catches followed by July recruitment to the wing trawl (Figure 20).

Bay anchovies were the most abundant species collected in each sound by each gear and were also taken in Lake Phelps and Lake

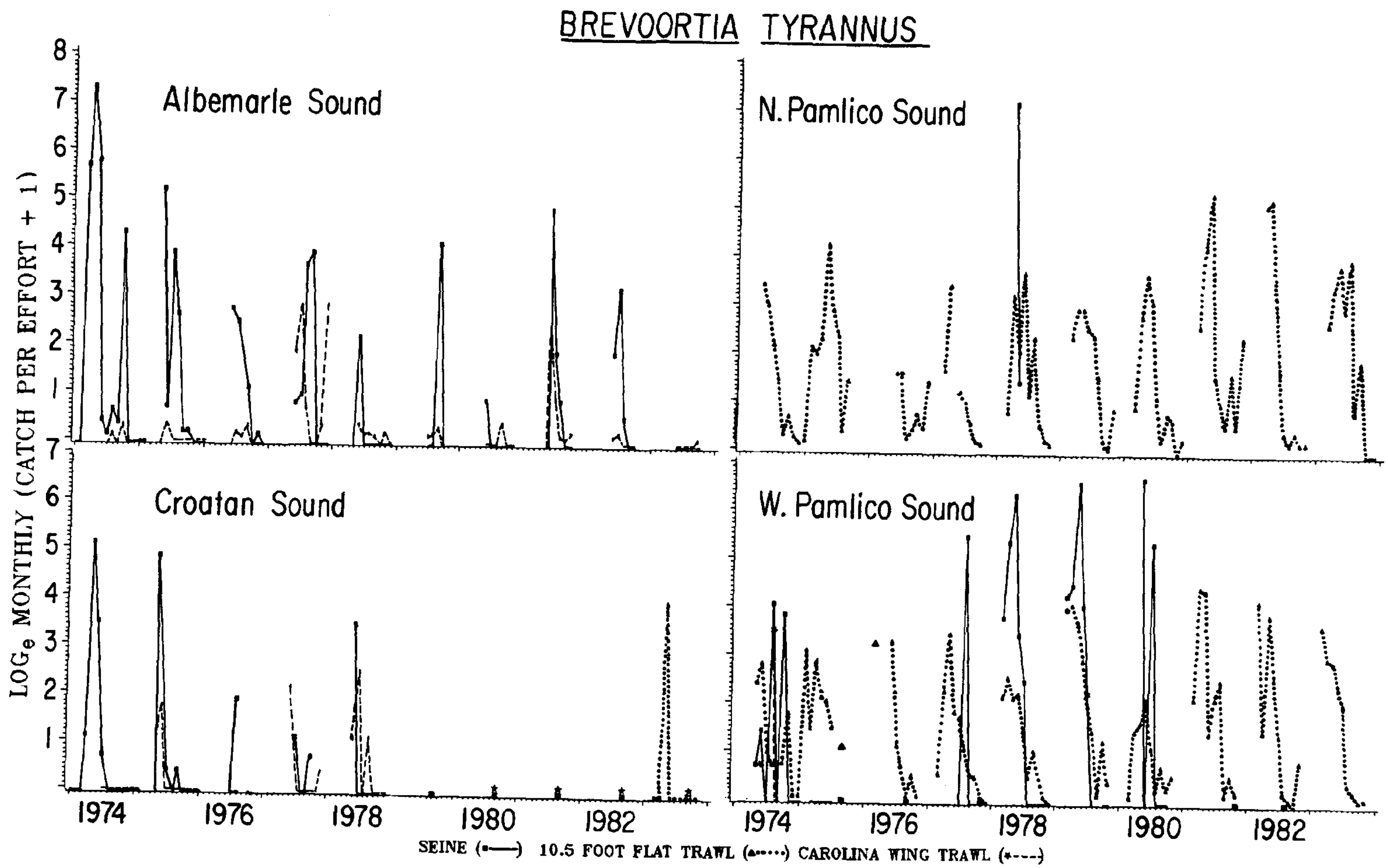

Figure 17. Brevoortia tyrannus monthly catch per effort.

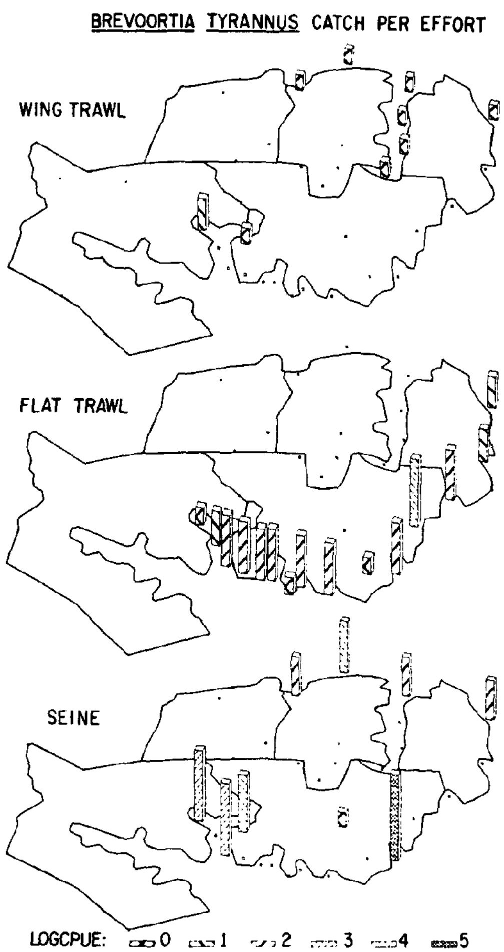

Figure 18. Geographical distribution of *Brevoortia tyrannus* catches.

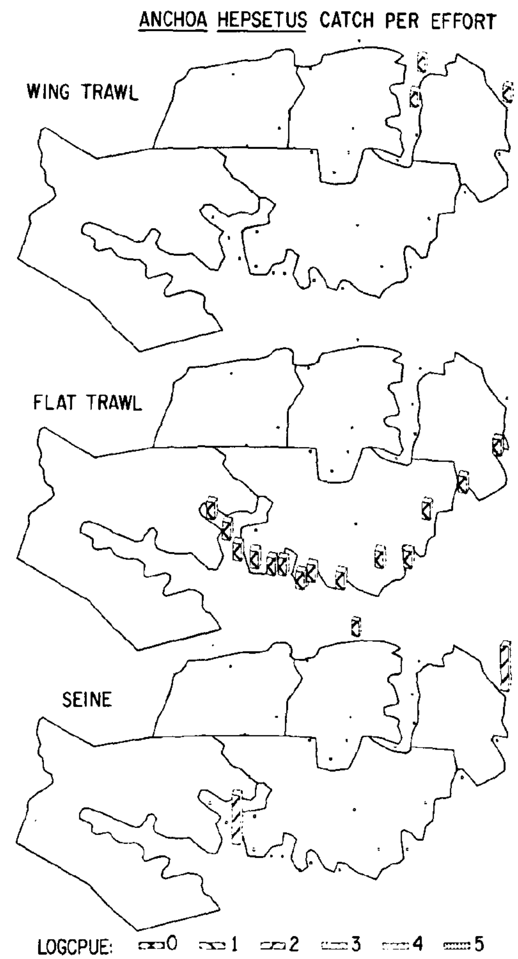

Figure 19. Geographical distribution of *Anchoa hepsetus* catches.

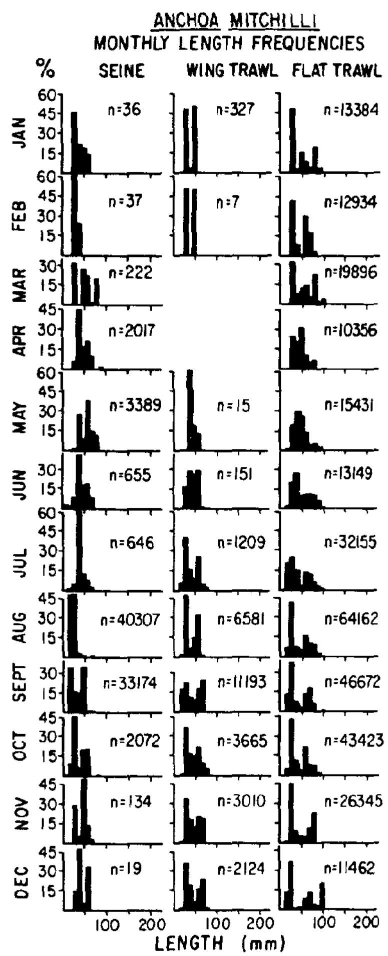

Figure 20. Monthly length frequencies of Anchoa mitchilli.

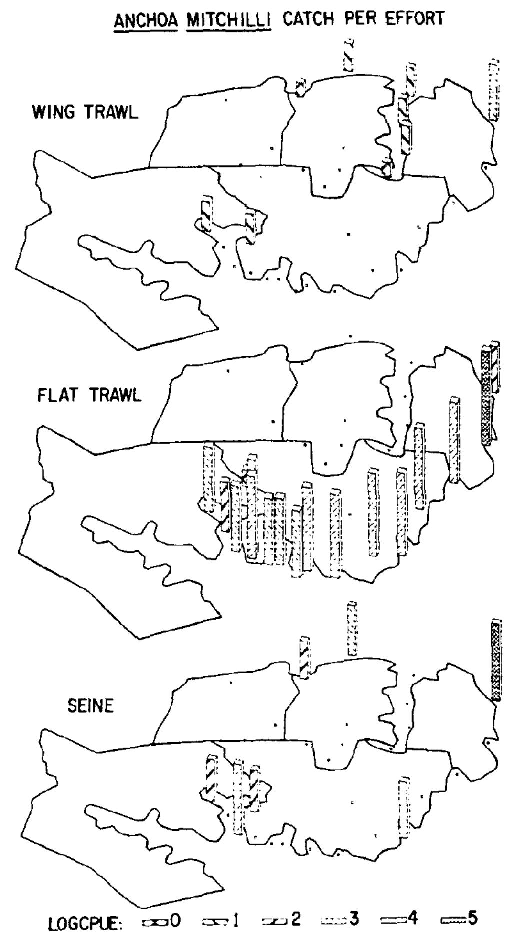

Figure 21. Geographical distribution of Anchoa mitchilli catches.

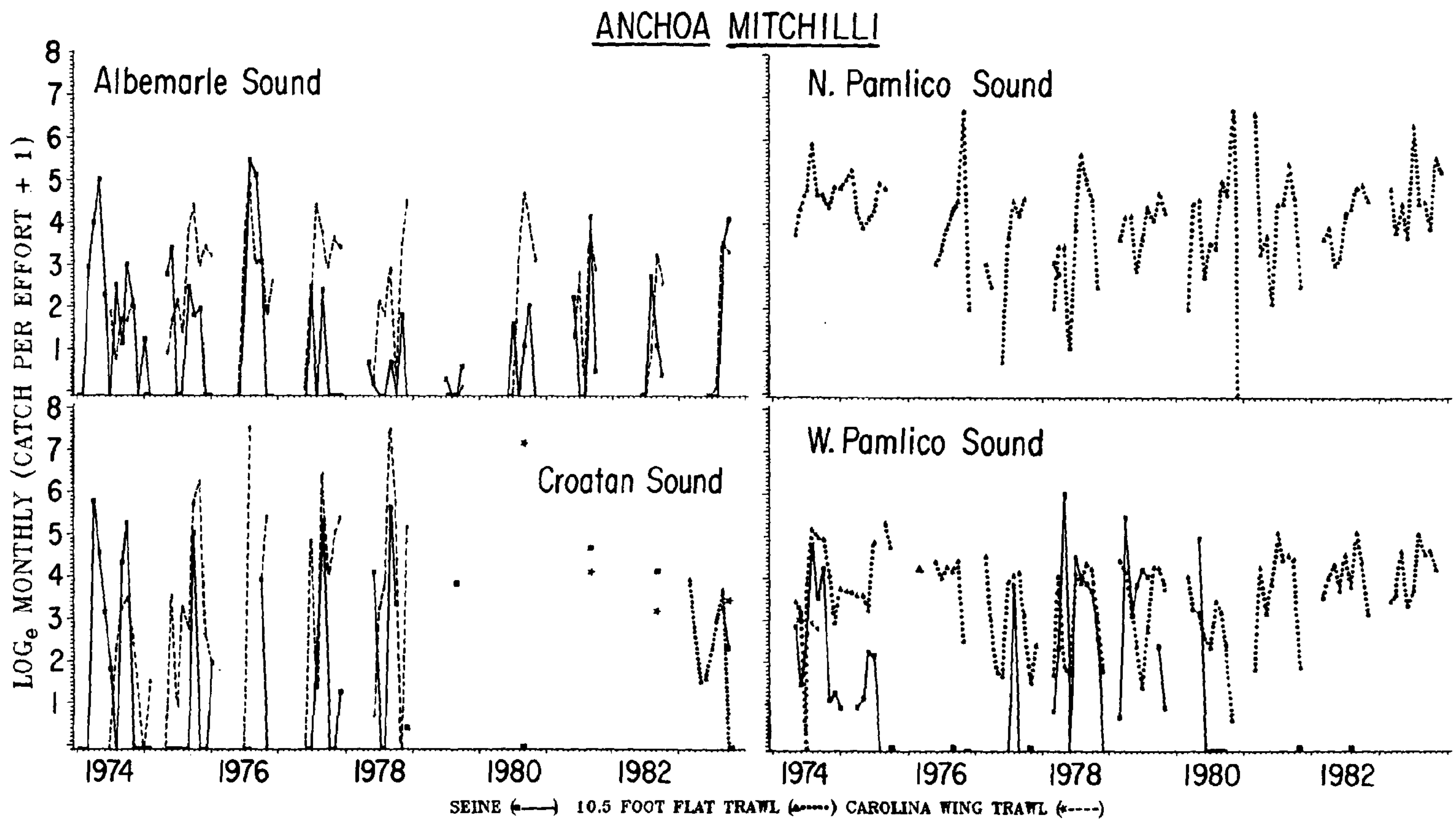

Figure 22. Anchoa mitchilli monthly catch per effort.

Mattamuskeet. The species was collected over an extremely broad range of salinities but showed some geographical differences in distribution. Flat trawl catches in northern Pamlico Sound generally were higher than flat trawl catches of western Pamlico Sound and Croatan Sound seine and wing trawl catches were higher than Albemarle Sound catches (Figures 21, 22). Trawl catches in any area were usually comparable to and more consistent than the seine catches despite the inherent problems associated with sampling a pelagic species with a bottom trawl.

Notropis hudsonius

The spottail shiner is a bottom dwelling fish that is usually solitary but schools when spawning (Scott and Crossman 1973). The spawning season is protracted from late spring through summer (Jones et al. 1978) and juveniles begin recruiting in June (Figure 23).

N. hudsonius was abundant in Albemarle Sound collections taken either in the sound or near tributary mouths (Figure 24) at salinities less than 5.0 $^{o}/_{oo}$. The flat trawl collection in Pungo River was of a single individual taken in September 1974; all other catches were in Albemarle Sound and tributaries (Figure 24). Seine catches invariably exceeded wing trawl catches (Figure 25) indicating the species is an inhabitant of shallow nearshore areas.

Ictalurus catus

The white catfish is a coastal plain species common in waters of less than 5 $^{o}/_{oo}$ salinity. Avoiding vegetation, it is frequently found over heavily silted areas. Spawning occurs in late spring in nests built near sand or gravel banks and offspring are guarded initially by the parents (Jones et al. 1978). Juveniles are recruited during June-September (Figure 26) and reach maturity in one to two years (Jones et al. 1978). Seine and flat trawl catches of I. catus were insignificant when compared to wing trawl catches in Albemarle Sound except for sporadically high catches in the upper Pungo River (Figure 27). Low catches in the spring, reflecting their spawning behavior, were followed by high summer catches of new recruits (Figure 28). Wing trawl catches in Albemarle Sound have declined since the mid to late 1970's.

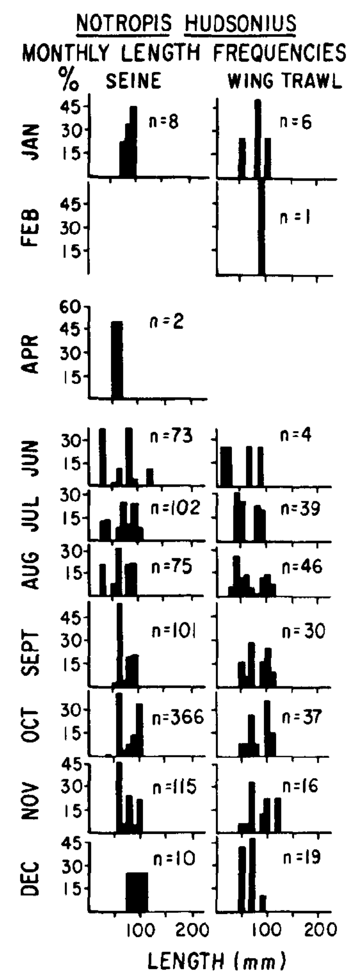

Figure 23. Monthly length frequencies of Notropis hudsonius.

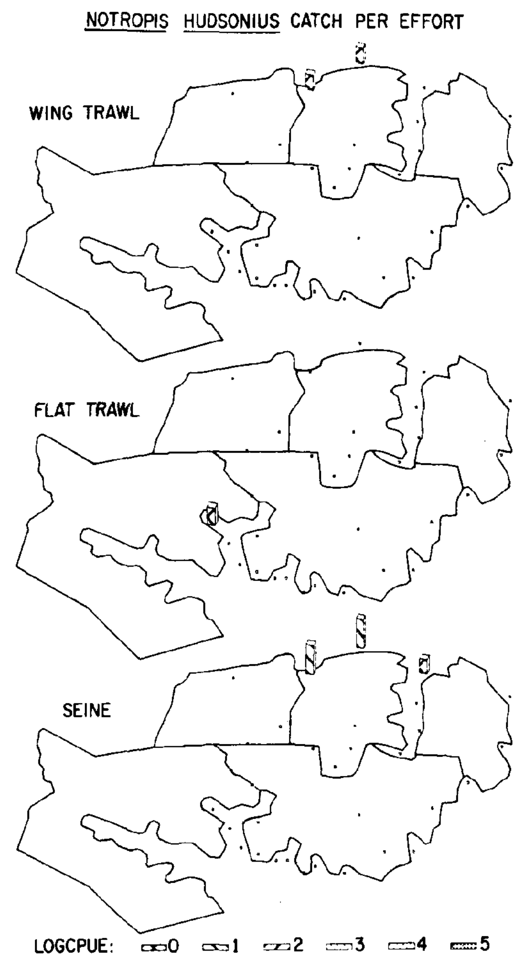

Figure 24. Geographical distribution of Notropis hudsonius catches.

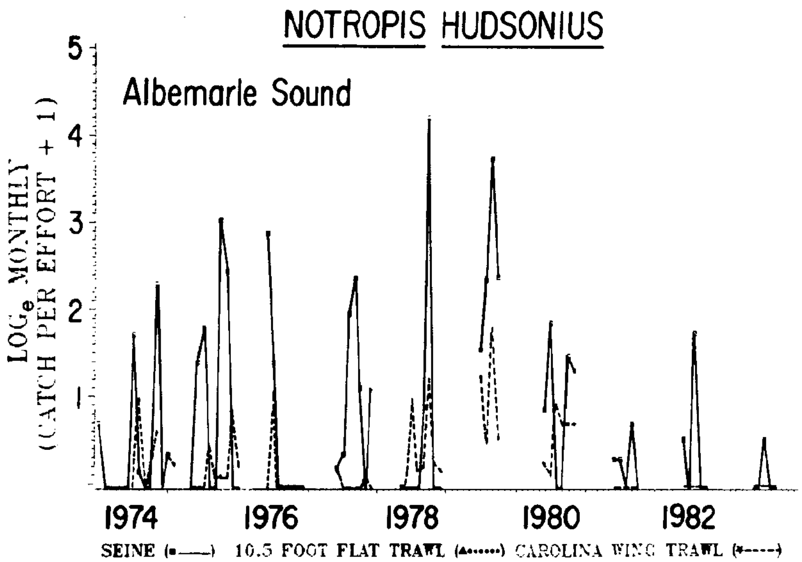

Figure 25.
Notropis hudsonius monthly catch per effort.

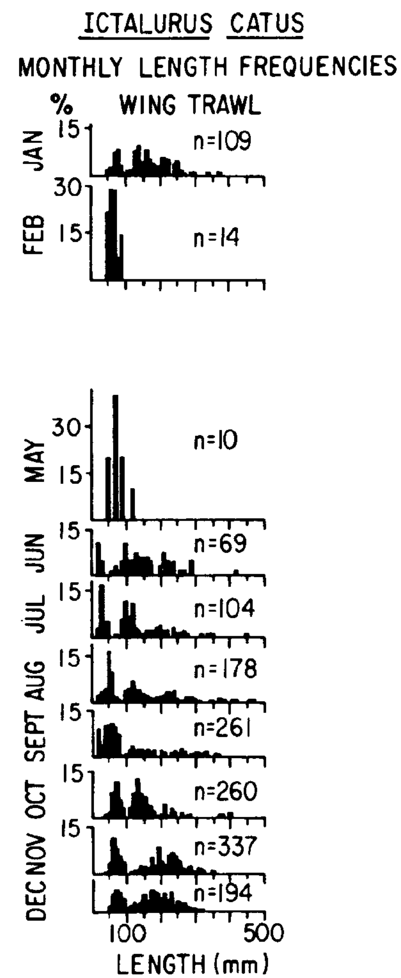

Figure 26. Monthly length frequencies of Ictalurus catus.

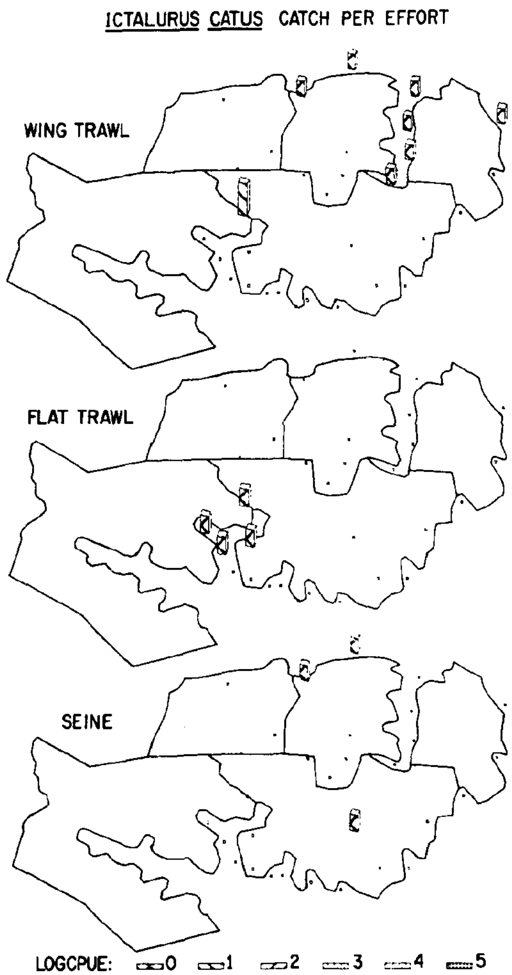

Figure 27. Geographical distribution of *Ictalurus catus* catches.

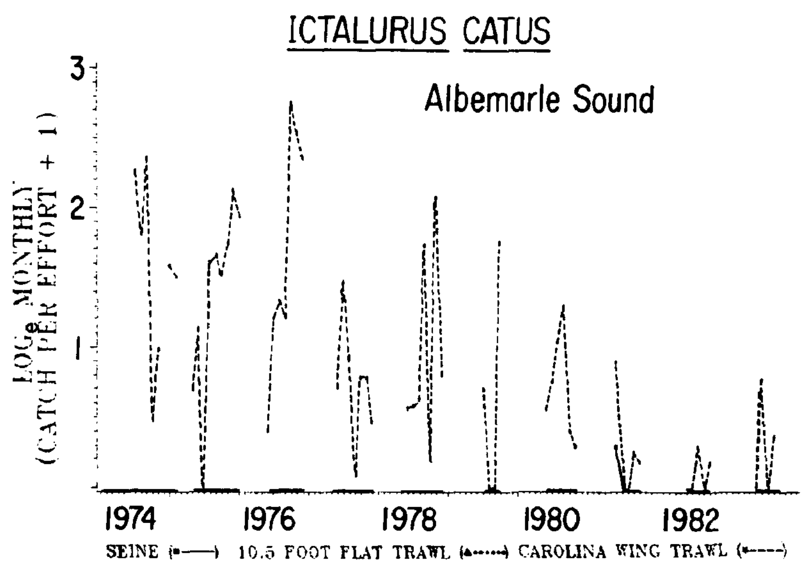

Figure 28.
Ictalurus catus monthly catch per effort.

The Albemarle Sound area contributes approximately 90% of North Carolina's catfish landings (Harriss 1982). Catfish are taken primarily in pound nets, gill nets, and fish pots. *I. catus* and *I. punctatus* are the dominant species in the catches; white catfish are usually more common than channel catfish (Keefe and Harriss 1980). Catfish landings on the peninsula have varied by over 100%, peaking in recent years during 1977 (Appendix A). White catfish do not grow as large or live as long as channel catfish and those landed in the 1980 and 1981 commercial fishery were predominantly age 3 and 4 (Harriss 1982), reflecting the relatively large year classes of *I. catus* also represented in DMF sampling on the peninsula in the middle to late 1970's.

Strongylura marina

The Atlantic needlefish is primarily an inshore, shallow water species that frequently enters freshwater. Spawning occurs in the spring inside the estuary (Hardy 1978a) and young recruits are first encountered in seine collections in May (Figure 29). Juveniles utilize the low salinity areas, emigrating in the fall. Because individuals are upper water column residents and are extremely agile, trawl catches of *S. marina* were almost non-existent and do not reflect the abundance of the species in an area (Figure 30). The trawl collection of *S. marina* in the lower Pungo River represents a single individual. Adults utilize the peninsula's waters but because of their agility were not usually captured with a seine. Hence, the monthly seine CPUE catches (Figure 31) primarily reflect the abundance of juvenile Atlantic needlefish.

Membras martinica

The rough silverside is an estuarine resident commonly found in the higher salinity areas of the estuary. Spawning is protracted from late spring to fall and probably occurs among vegetation (Hildebrand and Schroeder 1928). Young-of-the-year recruit into seine collections from June through October (Figure 32). The rough silverside is a pelagic species which schools in shallow water and was not vulnerable to trawl efforts. Seine collections of *M. martinica* were highest in Croatan Sound and in the Pungo River, but were quite variable in all areas

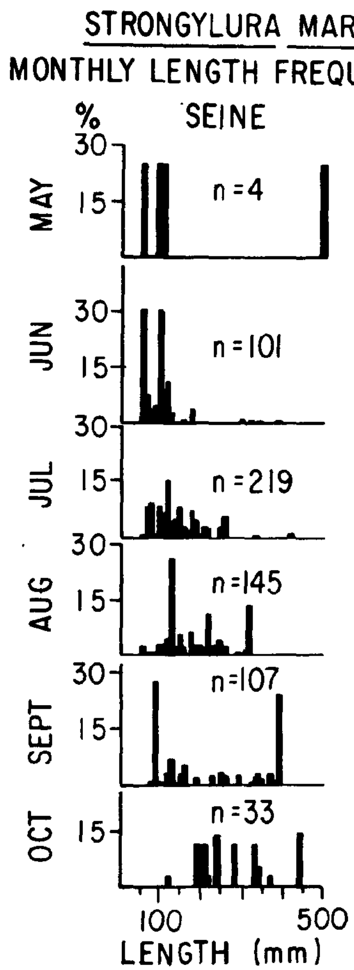

Figure 29. Monthly length frequencies of *Strongylura marina*.

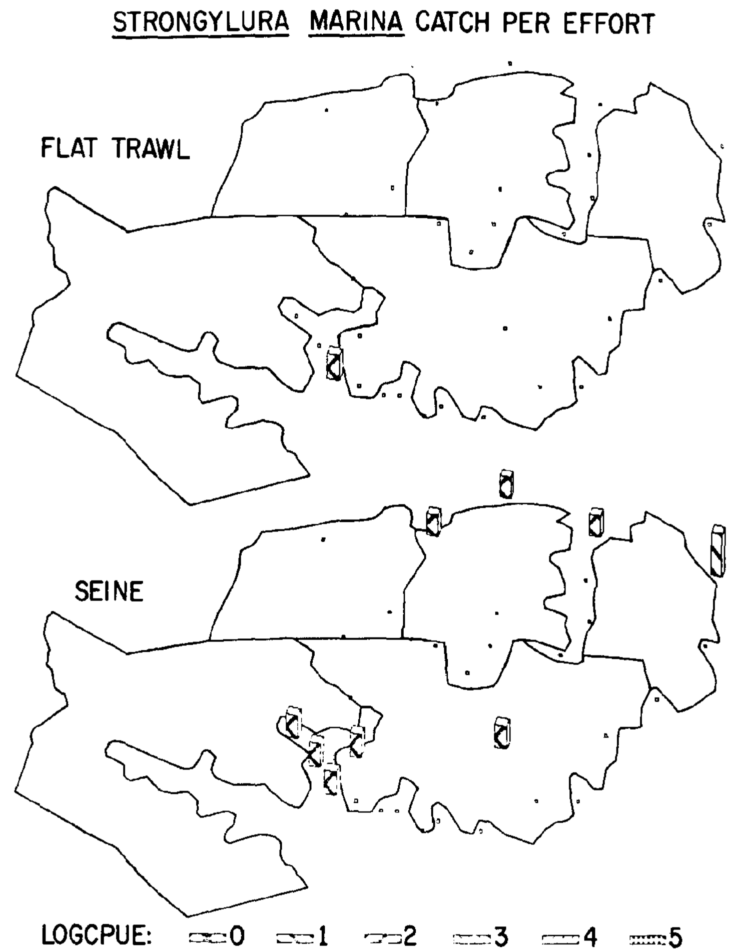

Figure 30. Geographical distribution of *Strongylura marina* catches.

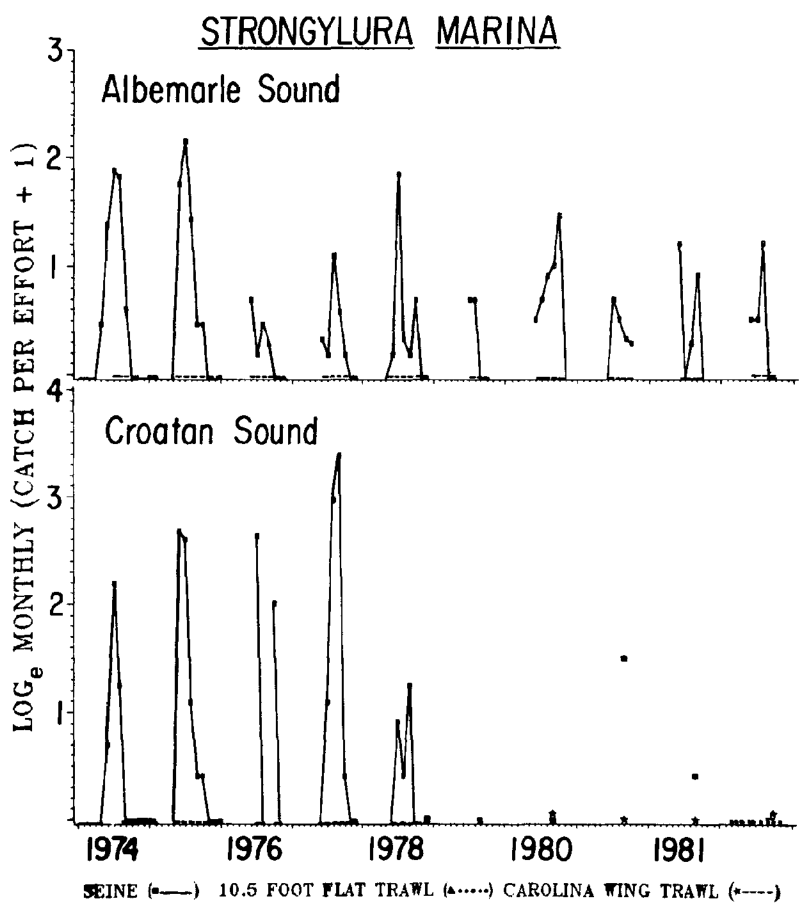

Figure 31.
Strongylura marina monthly catch per effort.

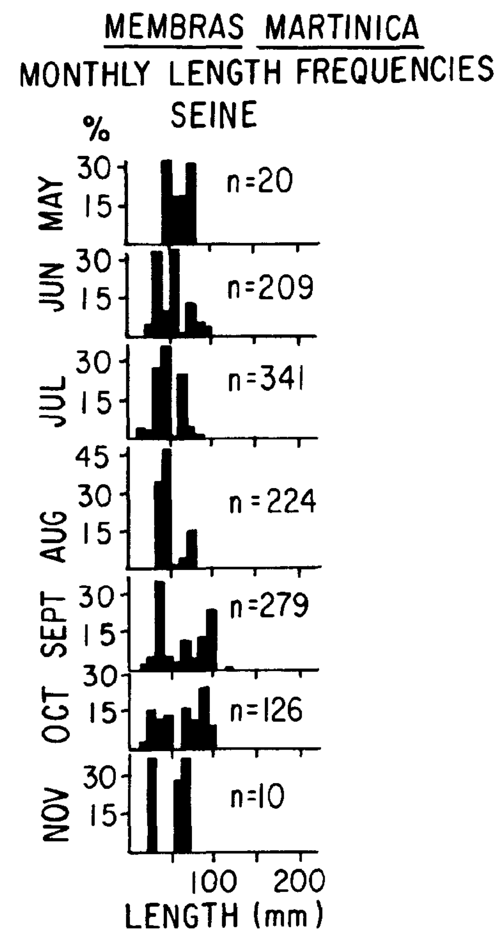

Figure 32. Monthly length frequencies of Membras martinica.

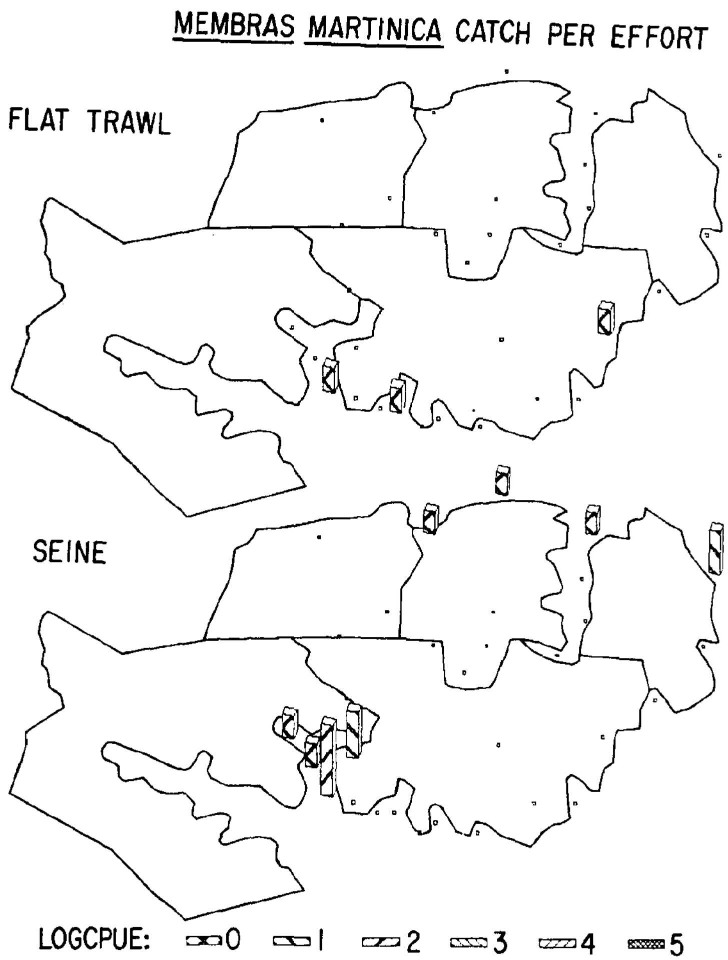

Figure 33. Geographical distribution of Membras martinica catches.

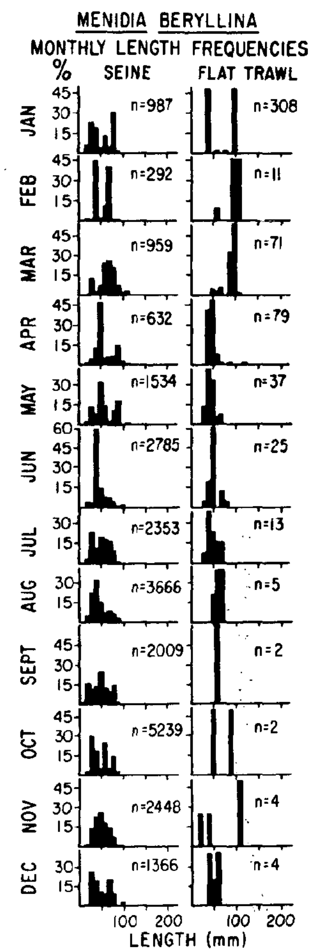

Figure 34. Monthly length frequencies of Menidia beryllina.

(Figure 33), precluding definition of its seasonal abundance on the peninsula.

Menidia beryllina

The inland silverside is an abundant, pelagic, estuarine resident of shallow coastal waters and is usually found in fresher waters than the rough and Atlantic silversides. The spawning season has been reported to extend throughout the spring and summer, with some individuals spawning more than once (Hildebrand 1922; Hardy 1978a), but recruitment as evidenced by the seine catches occurs every month on the Pamlico-Albemarle Peninsula (Figure 34). Although variable, seine catches indicated a pattern of peak abundance in the summer and higher catches in the lower salinity waters of Albemarle Sound and western Pamlico Sound (Figure 35). Few were collected in northern Pamlico Sound, primarily due to the lack of seine effort in that area (Figure 36), but when effort was made, the inland silverside was very abundant. Trawl catches of the inland silverside were insignificant when compared to the seine catches.

Menidia menidia

The Atlantic silverside is an abundant pelagic species inhabiting shallow marine and brackish waters. Menidia menidia spawns from early spring to late summer among vegetation, particularily among Zostera in high salinity areas, and probably spawns more than once during a season (Hildebrand 1922). Recruiting young-of-the-year first appear in June (Figure 37). The Atlantic silverside was seldom taken in the flat trawl collections and only then at stations north of Bluff Shoal; it was never collected with the wing trawl (Figure 38). Although it does enter freshwater, it was most common nearest the closest inlet, in Croatan Sound. Monthly CPUE was sporadic in all areas but M. menidia was consistently captured in Croatan Sound seine collections (Figure 39).

Morone americana

North Carolina populations of white perch are considered estuarine residents (Conover 1958). Spawning occurs in April through June (Hardy 1978b) with juvenile recruits first appearing in June (Figure 40).

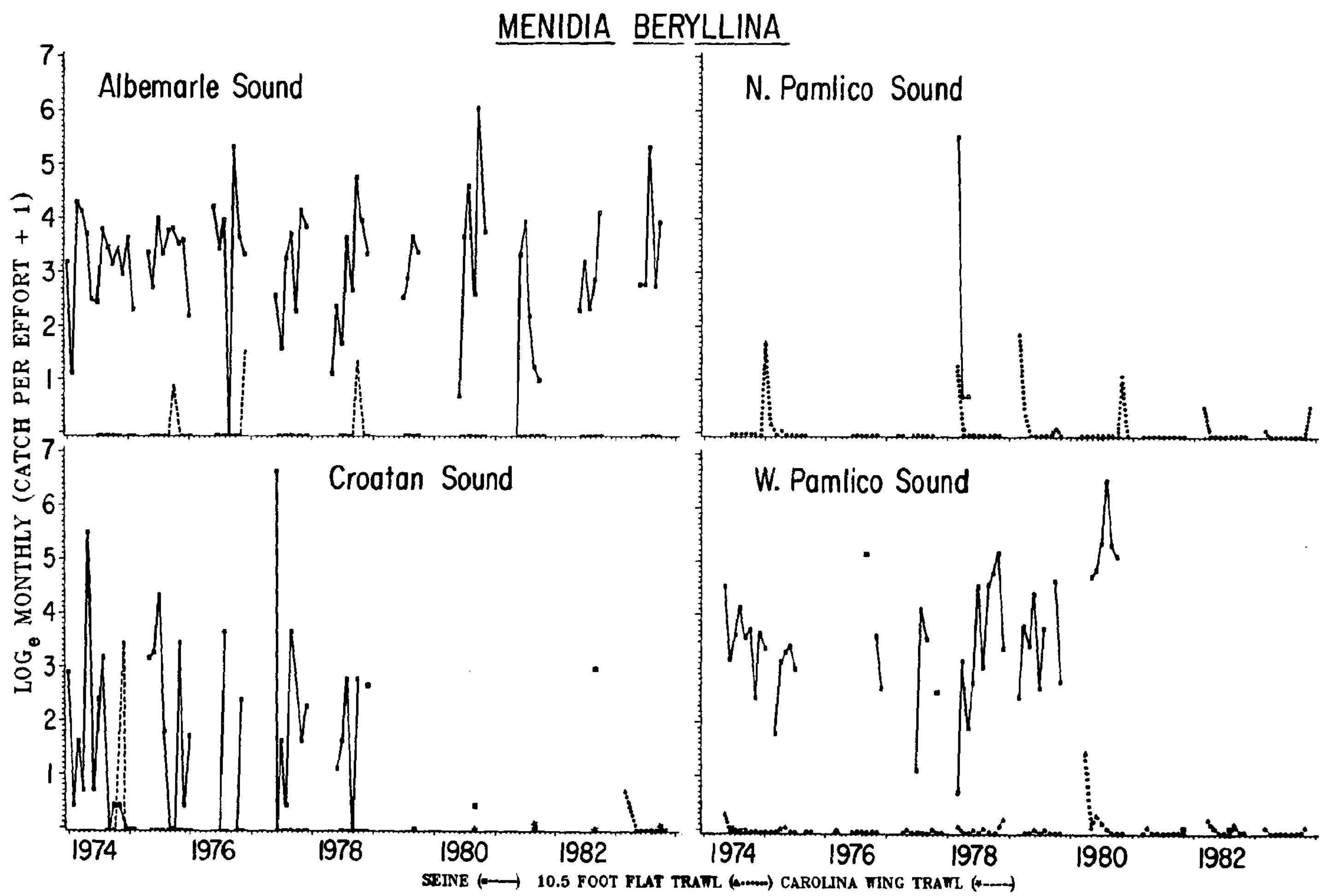

Figure 35. *Menidia beryllina* monthly catch per effort.

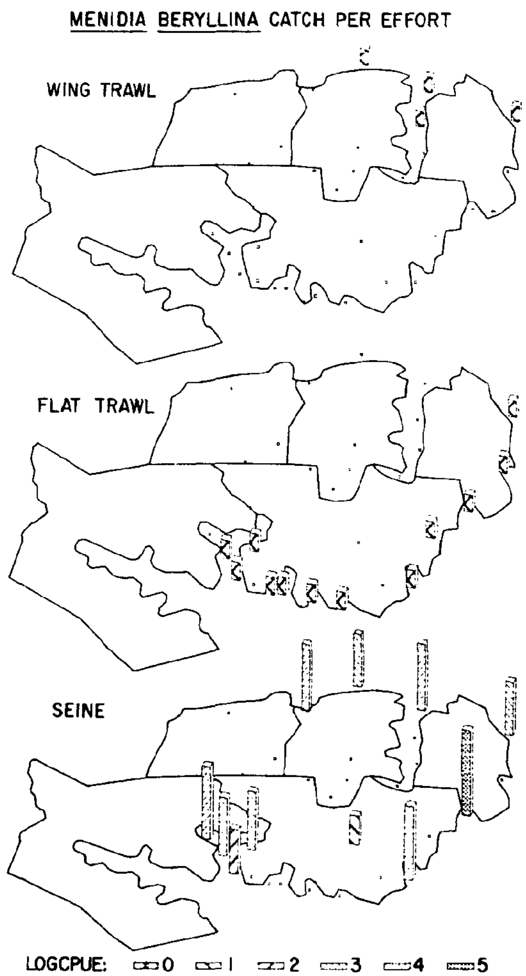

Figure 36. Geographical distribution of Menidia beryllina catches.

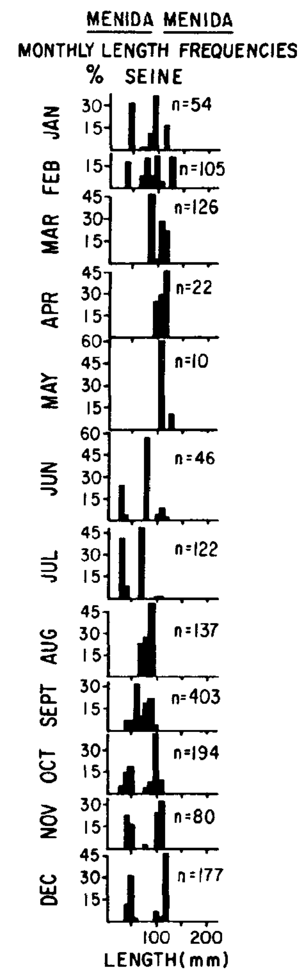

Figure 37. Monthly length frequencies of Menidia menidia.

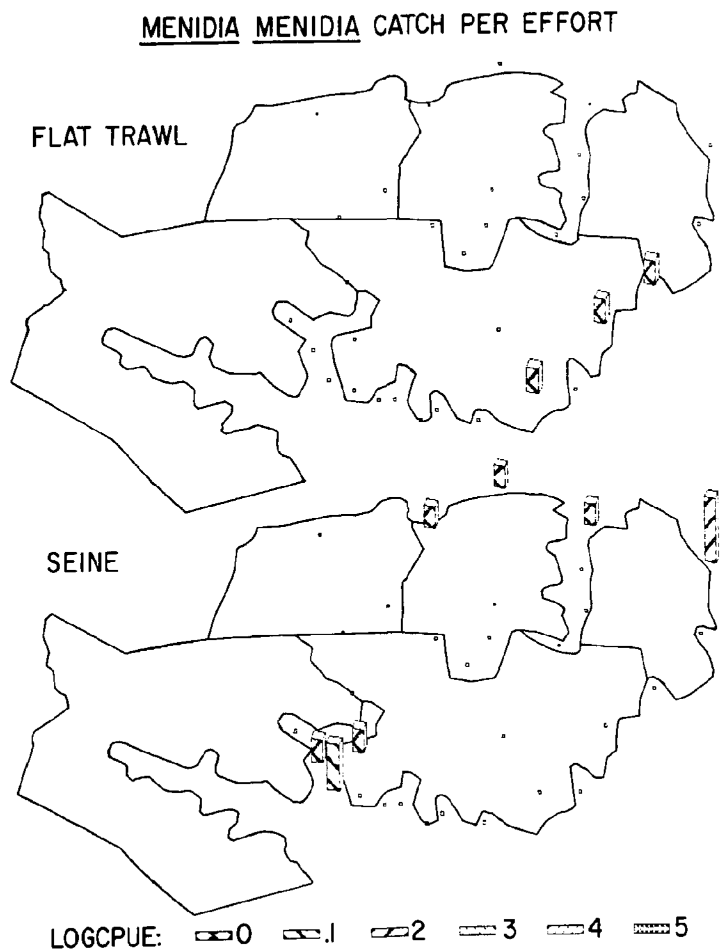

Figure 38.
Geographical distribution of Menidia menidia catches.

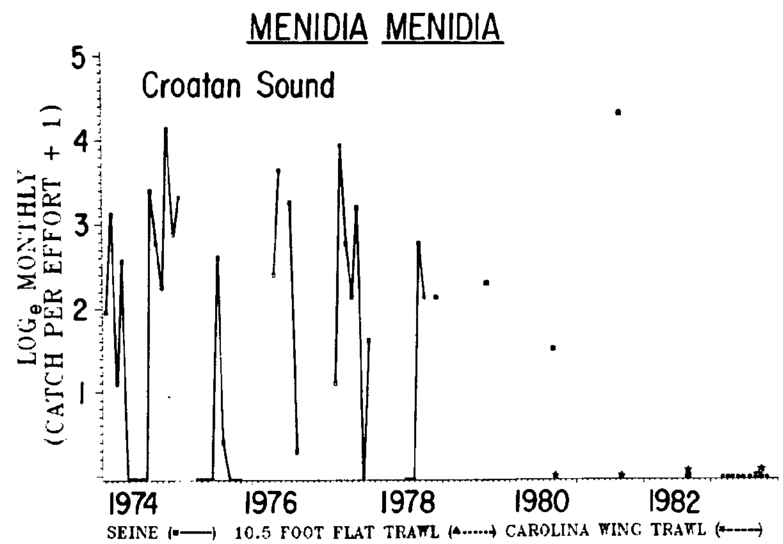

Figure 39.
Menidia menidia monthly catch per effort.

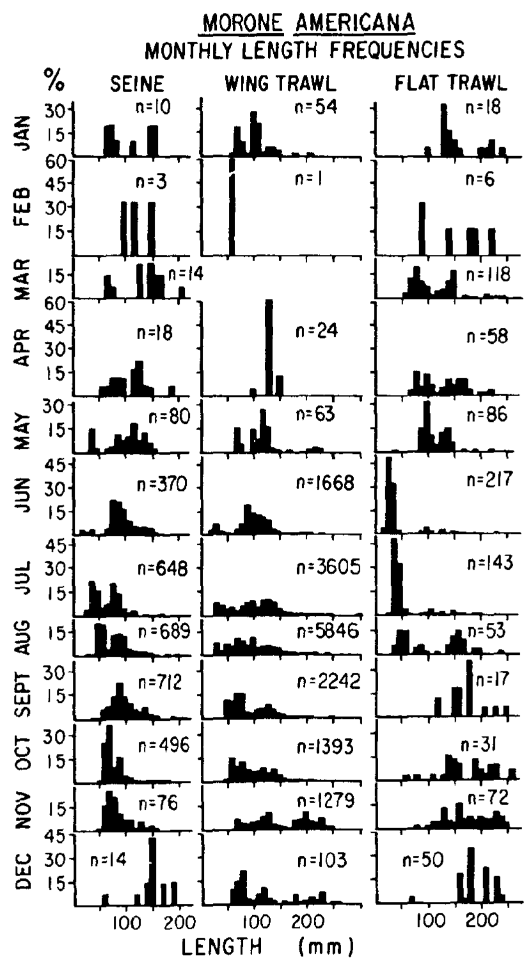

Figure 40. Monthly length frequencies of Morone americana.

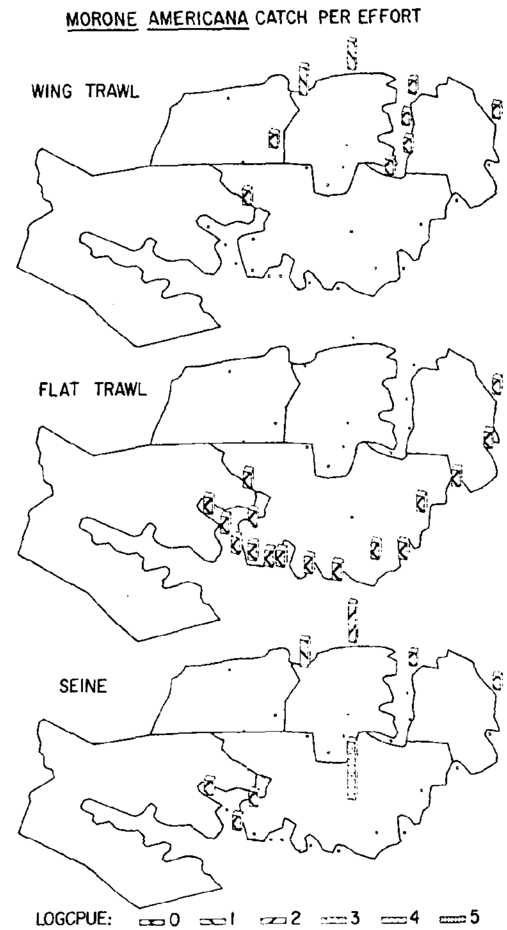

Figure 41. Geographical distribution of Morone americana catches.

Although most abundant in fresh and low salinity waters, individuals were collected at salinities as high as 30 $^{o}/oo$ and in all areas of the peninsula except New Lake (Figure 41). Wing trawl and seine collections in Albemarle Sound were much higher than catches in all other areas except Lake Mattamuskeet. Monthly CPUE data from Albemarle Sound collections illustrate a peak abundance in the summer coinciding with recruiting young-of-the-year and a spring and fall migration, respectively, into and out of the study area (Figure 42). White perch migrate to the western Albemarle Sound basin and reach peak biomass in the sound during the winter months (Hester and Copeland 1975). The populations of white perch in Lake Phelps and Lake Mattamuskeet showed a peak in abundance in the summer. Seine and wing trawl catches during 1978-1981 were high relative to the other years (Figure 42).

The majority of the state's white perch landings are from the Albemarle Sound area where they are captured in haul seines, pound nets and gill nets.[1] Landings on the peninsula in five of the last six years have been higher than in any of the previous 15 years (Appendix A). Harriss (1982) noted that white perch in the Albemarle Sound 1978-1981 commercial landings were predominately ages 3 and 4.

Lagodon rhomboides

Pinfish spawn offshore in late fall and winter (Johnson 1978). Pelagic larvae are carried into the estuary by onshore currents and juveniles begin recruiting as early as February (Figure 43). Abundance peaks in late June (Figure 44) declining thereafter as young-of-the-year move to deeper water with growth (Johnson 1978). Some individuals remain in shallow water throughout the winter. Wing trawl and seine catches of *L. rhomboides* in Albemarle Sound and Croatan Sounds were low and always occurred in the fall (Figure 45). Flat trawl catches in Pamlico Sound were high, with stations west of Bluff Shoal having a consistently higher CPUE than stations north of the shoal.

Bairdiella chrysoura

Silver perch spend most of their lives within the estuary but regularly migrate to deeper waters and offshore in the winter (Johnson 1978). Spawning occurs within the estuarine zone between late April and

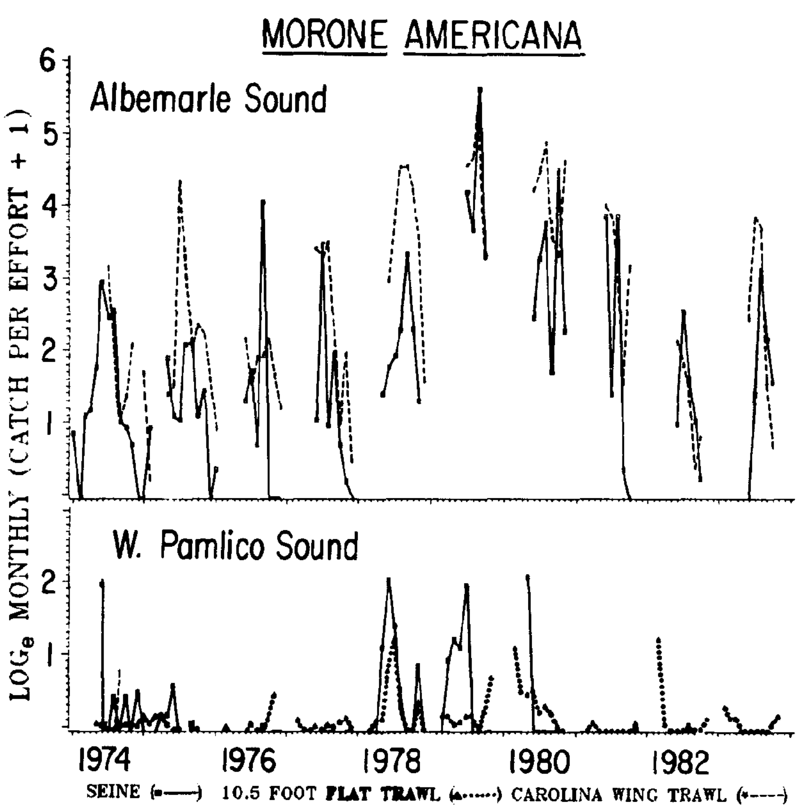

Figure 42.
Morone americana monthly catch per effort.

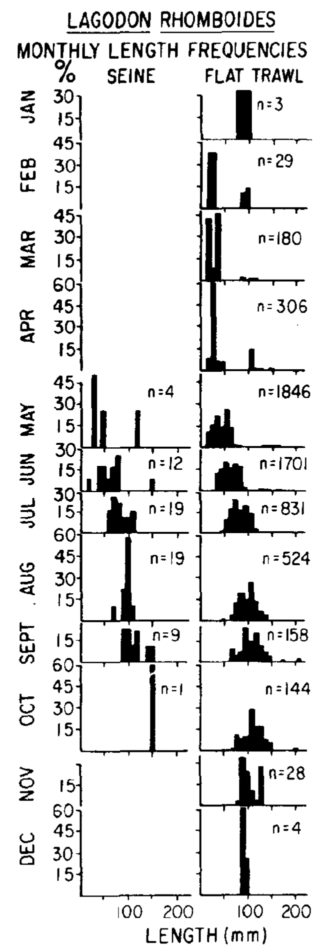

Figure 43. Monthly length frequencies of Lagodon rhomboides.

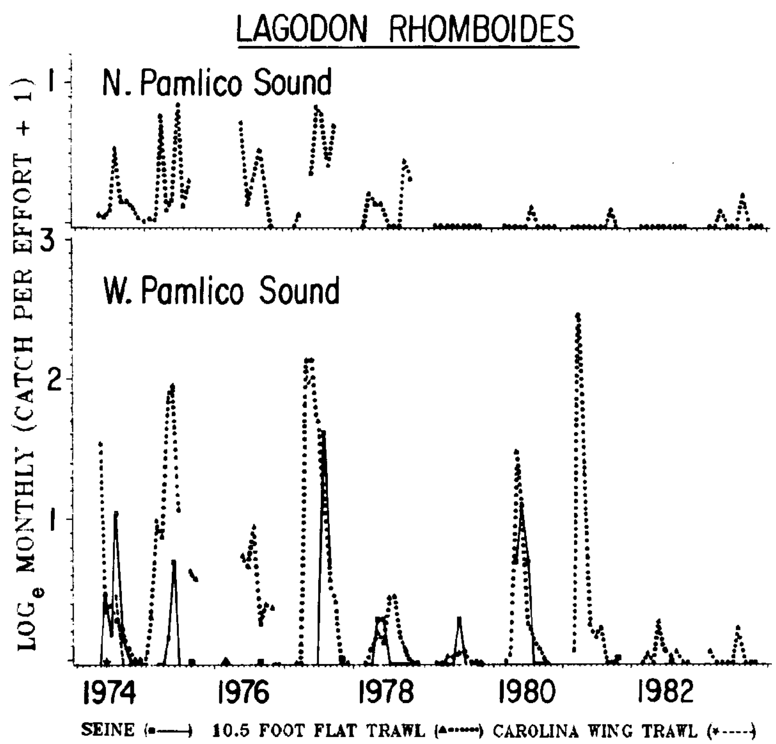

Figure 44.
Lagodon rhomboides monthly catch per effort.

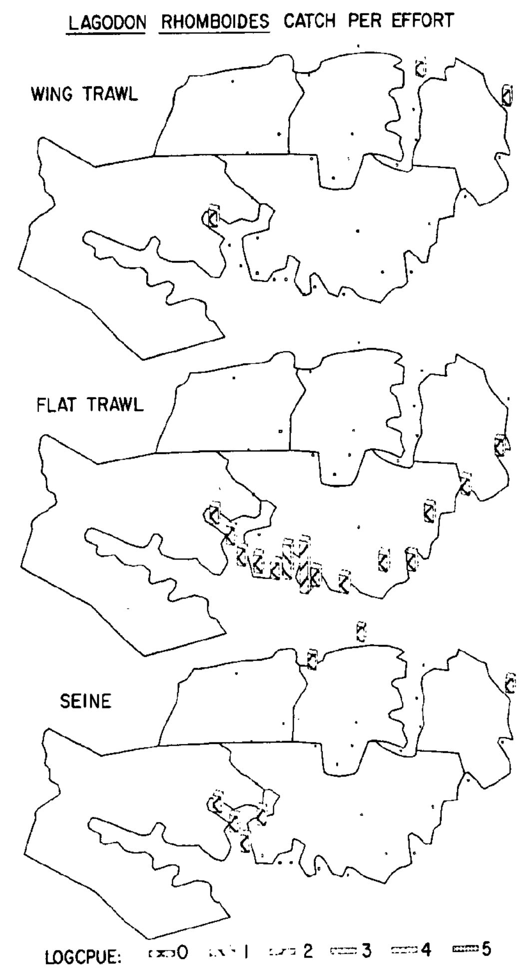

Figure 45. Geographical distribution of Lagodon rhomboides catches.

the middle of July (Hildebrand and Cable 1930) and juveniles are first captured in June (Figure 46). Abundance patterns reflect the high summer recruitment of young-of-the-year and the seasonal migration of yearlings and older fish into the peninsula's waters in the spring and emigration in the fall (Figure 47). Although tolerant of a broad range of salinities, most individuals were taken in the higher salinity waters of northern Pamlico Sound. Seine and wing trawl catches in Croatan and Albemarle sounds were sporadically high, but did not illustrate any pattern of abundance in those areas (Figure 48).

Cynoscion regalis

Weakfish are an important component of the nearshore environment, utilizing the estuary for spawning and juvenile nurseries, and moving offshore in the winter (Merriner 1973). Spawning occurs in the estuary and nearshore areas from March to October peaking primarily in May or June and secondarily in late July or August (Merriner 1976). Juveniles are most abundant over soft muddy substrates in deeper water (Johnson 1978; Hawkins 1982) and recruit in late spring through fall (Figure 49). Weakfish prefer high salinity water and were captured most frequently in Pamlico Sound stations located north of Bluff Shoal (Figure 50). Seine and wing trawl catches (mainly in shallow or low salinity areas) were small, emphasizing the juveniles' preference for deeper, higher salinity areas. Monthly CPUE data indicated a regular pattern of young-of-the-year recruitment peaking in the summer, followed by their emigration in the fall (Figure 51); some juveniles overwintered.

Weakfish are primarily caught in the winter trawl fishery off Virginia and North Carolina (Mercer 1983) but gill net, pound net and haul seine fisheries also contribute significantly to North Carolina's landings.[1] The dramatic increase in weakfish landings on the peninsula corresponds to greatly increased winter trawl landings beginning in 1972 (Appendix A).

Leiostomus xanthurus

Spot is a migratory marine species spawning offshore during October through February, but principally in December and January (Johnson 1978). Juveniles begin recruiting in February (Figure 52) reaching peak

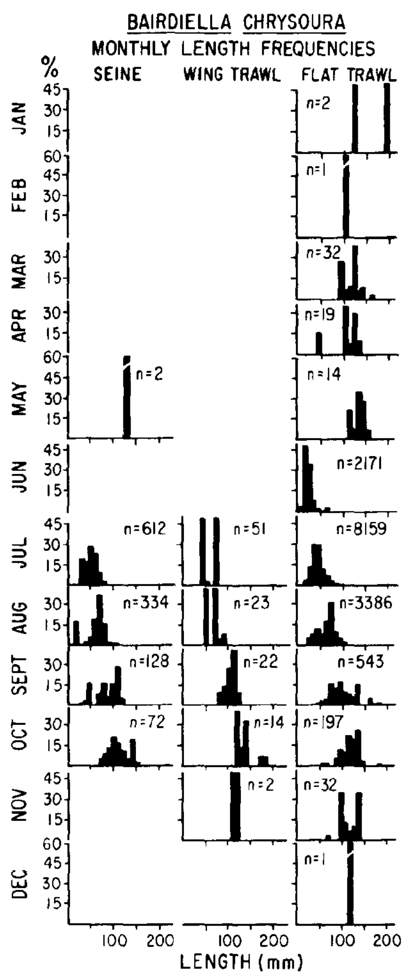

Figure 46. Monthly length frequencies of Bairdiella chrysoura.

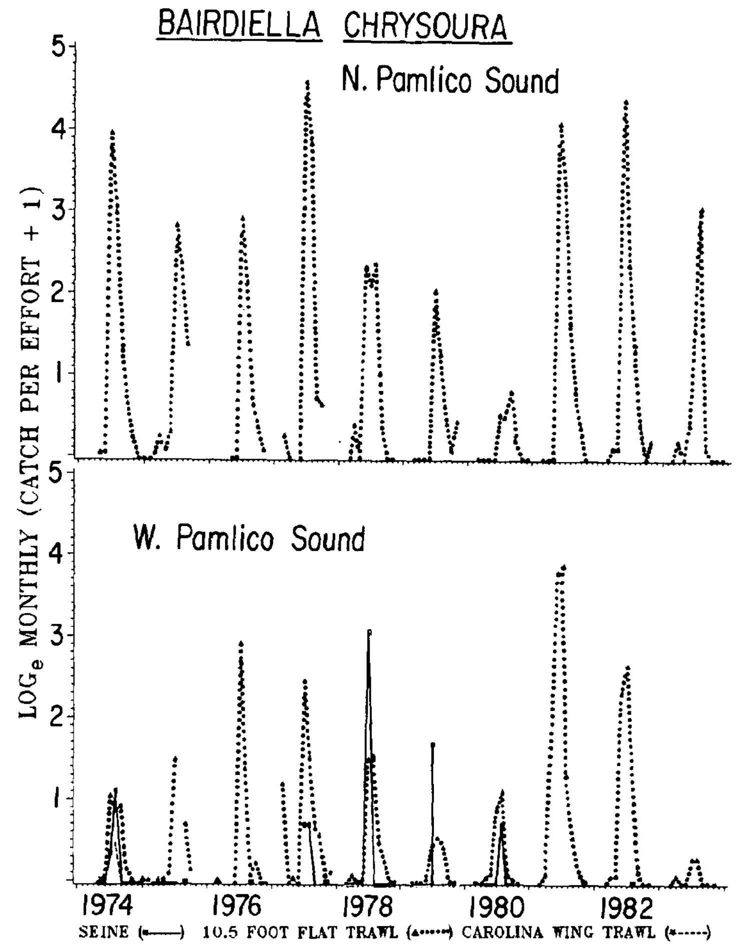

Figure 47.
Bairdiella chrysoura monthly catch per effort.

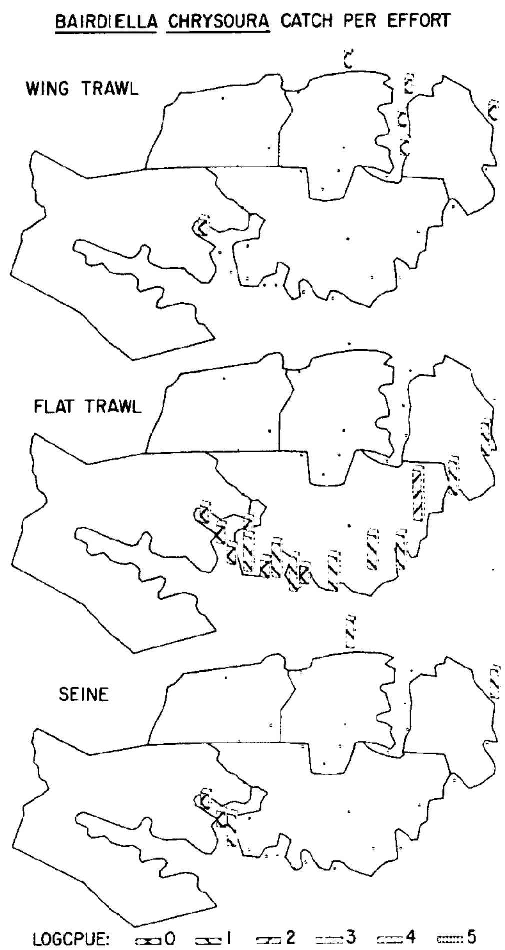

Figure 48. Geographical distribution of Bairdiella chrysoura catches.

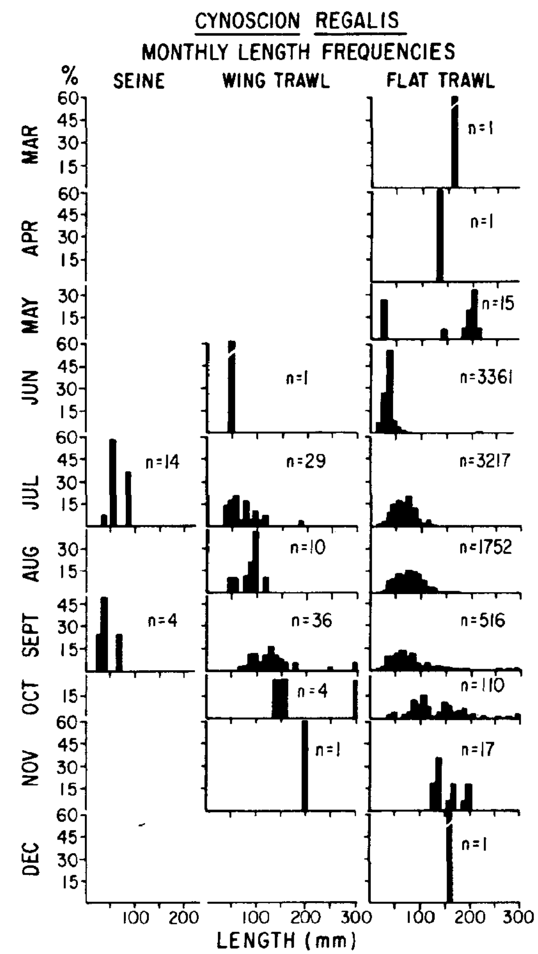

Figure 49. Monthly length frequencies of Cynoscion regalis.

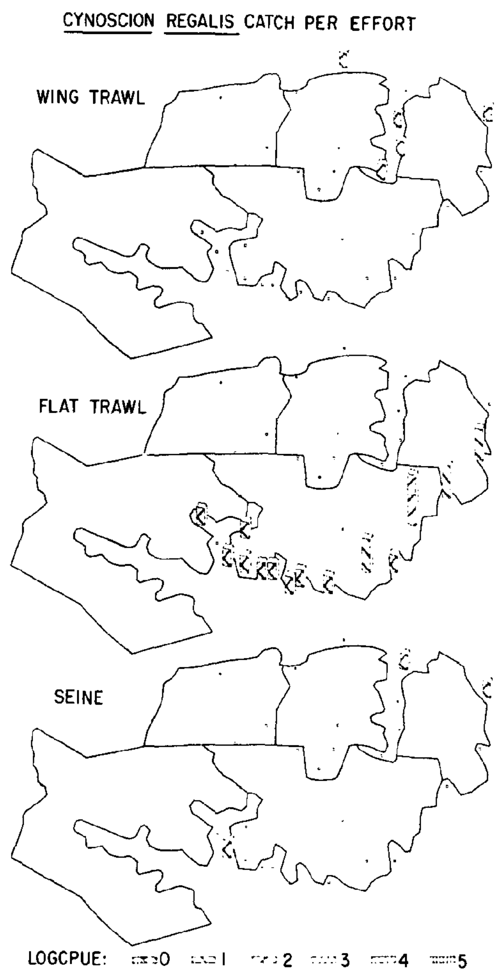

Figure 50. Geographical distribution of *Cynoscion regalis* catches.

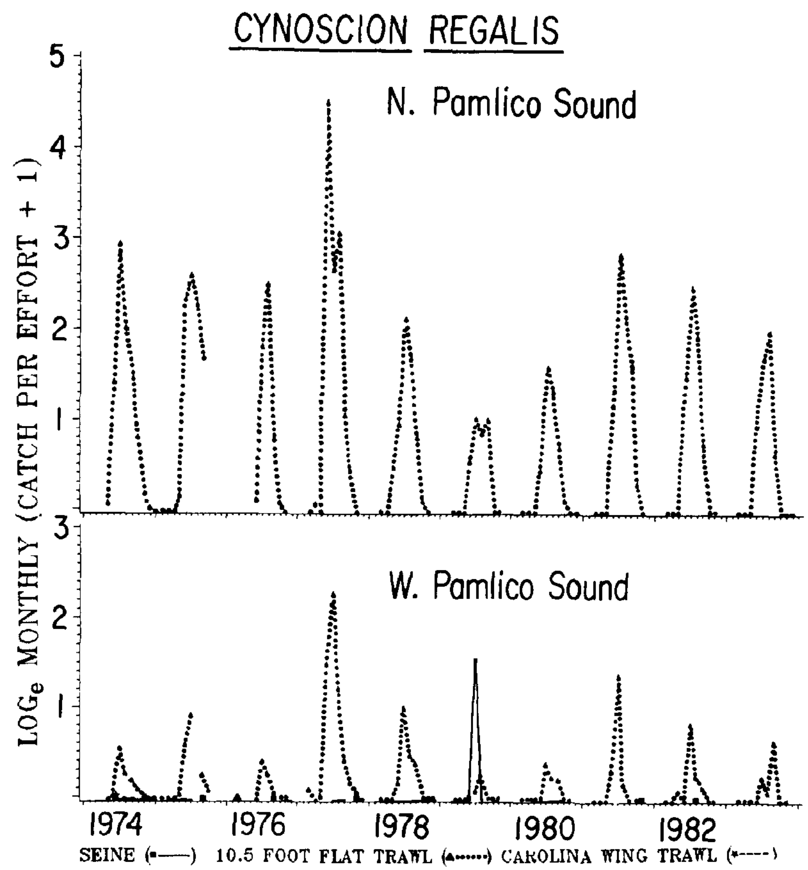

Figure 51.
Cynoscion regalis monthly catch per effort.

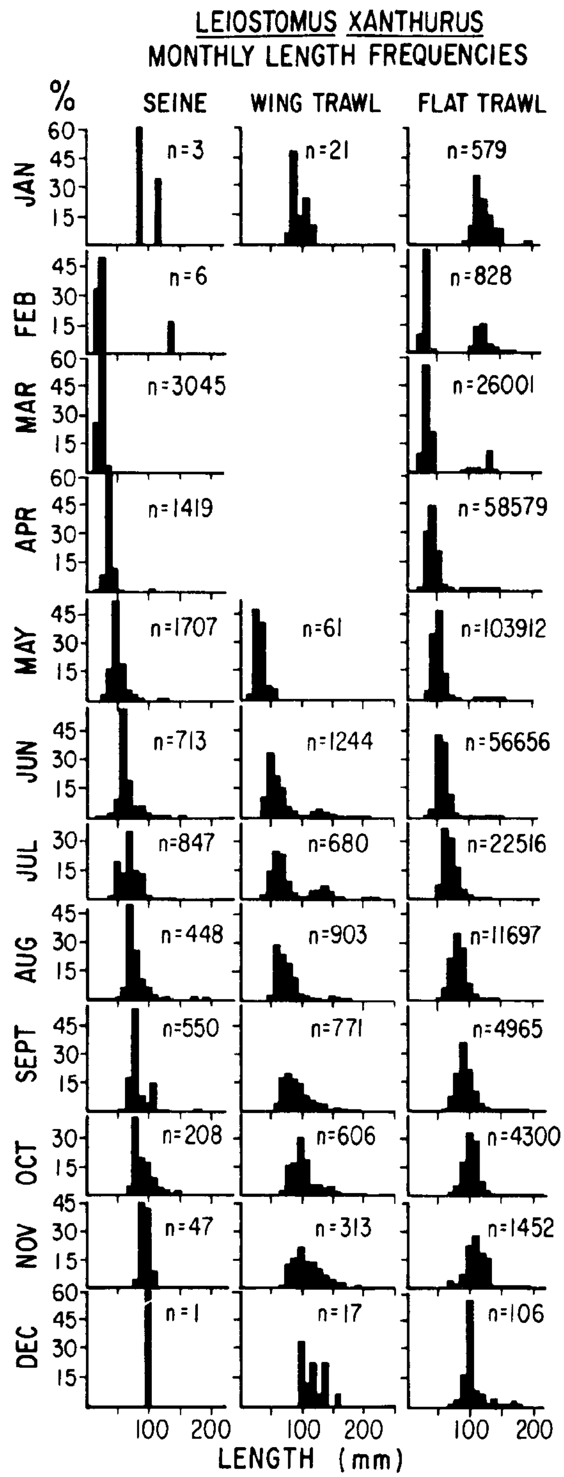

Figure 52. Monthly length frequencies of Leiostomus xanthurus.

abundance in May (Figure 53). Catches throughout the year are predominately of young-of-the-year, but overwintering yearlings were present in late winter and early spring. Monthly CPUE data reflect the spring recruitment, which occurred first in northern Pamlico Sound, and also reflects the late summer and fall emigration of the young-of-the-year. Spot were distributed throughout the peninsula in all areas except Lake Phelps, New Lake and Pungo Lake (Figure 54). It was one of the most common species collected but was most abundant in Pamlico Sound, particularly at stations west of Bluff Shoal.

Most spot landed in North Carolina are taken in the Pamlico and Core sounds long haul seine fishery and were the most abundant species sampled in that fishery (DeVries 1980). Most spot landed in the long haul fishery are age 1, but they begin to recruit to the fishery during their first fall after leaving the nursery areas (Ross 1982). L. xanthurus is also taken in significant quantities in the pound net, gill net and winter trawl fisheries.[1] State landings peaked in 1979 and 1980 which were also years of high spot landings on the peninsula (Appendix A).

Micropogonias undulatus

Spawning of Atlantic croaker off North Carolina is protracted, occurring from September to March, but peaking in October (Warlen 1980). Juvenile recruitment occurs in all except the summer months but is highest in the spring (Figure 55). A second peak in recruitment occurs during the fall but is generally restricted to the northern Pamlico Sound stations (Figure 56). Late winter and spring recruited croaker leave the nursery areas at the end of the summer and in the fall, but a few may overwinter with the fall recruits. Like spot, croaker were distributed throughout the peninsula but unlike spot, they were most abundant in Pamlico Sound north of Bluff Shoal (Figure 57).

The winter trawl and long haul fisheries jointly account for most of North Carolina's croaker landings, although in recent years the sink net and pound net fisheries have also contributed significantly to the landings.[1] Croaker are fully recruited to the fisheries by age 1 but young-of-the-year begin recruiting by their first fall. Most croaker landed in North Carolina are yearlings although at least seven age

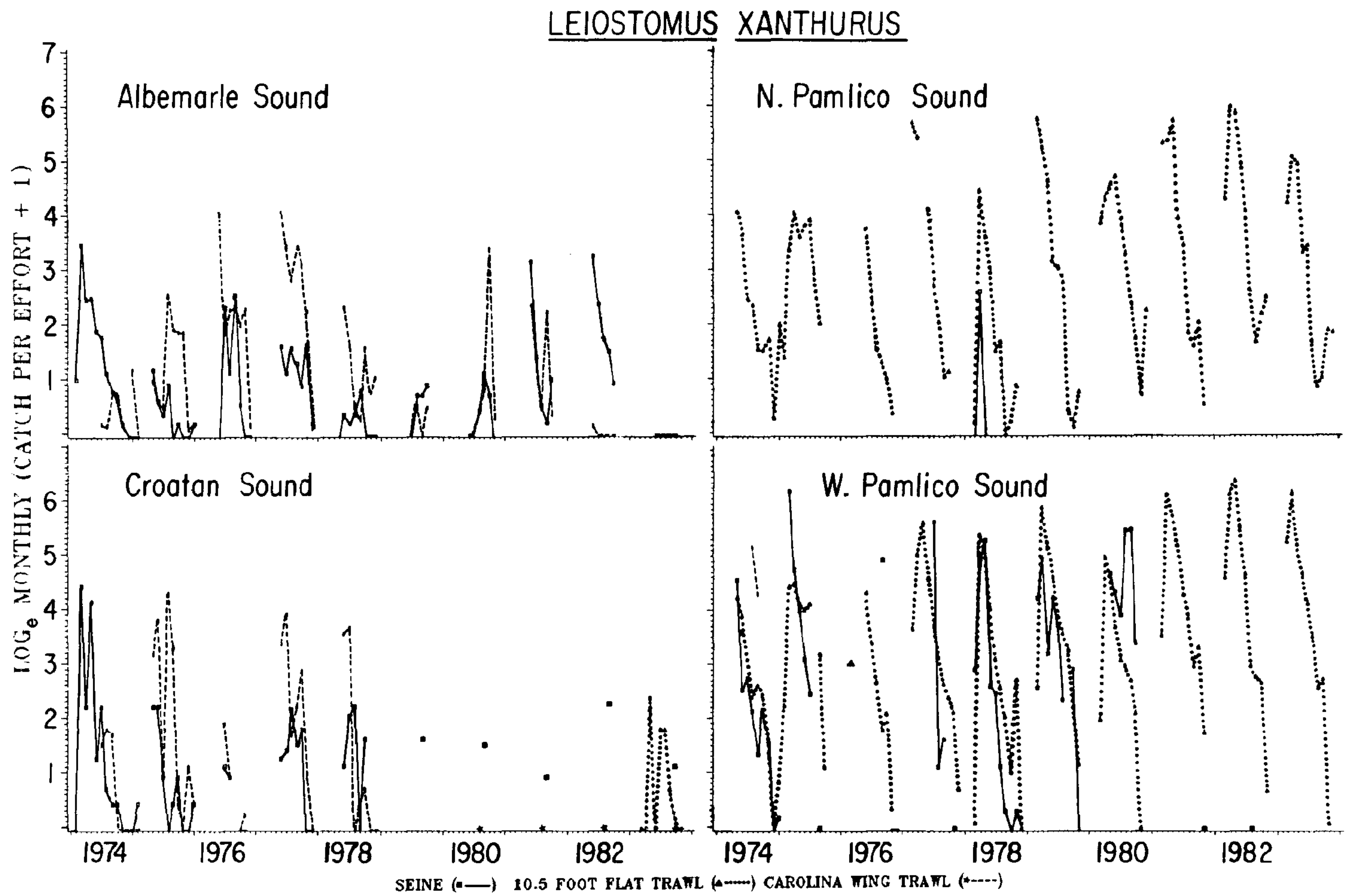

Figure 53. Leiostomus xanthurus monthly catch per effort.

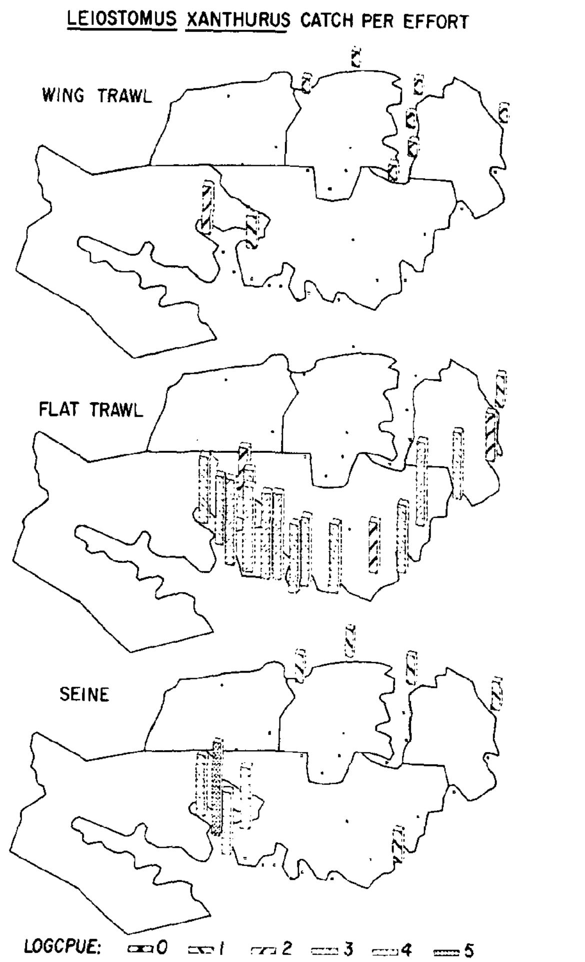

Figure 54. Geographical distribution of Leiostomus xanthurus catches.

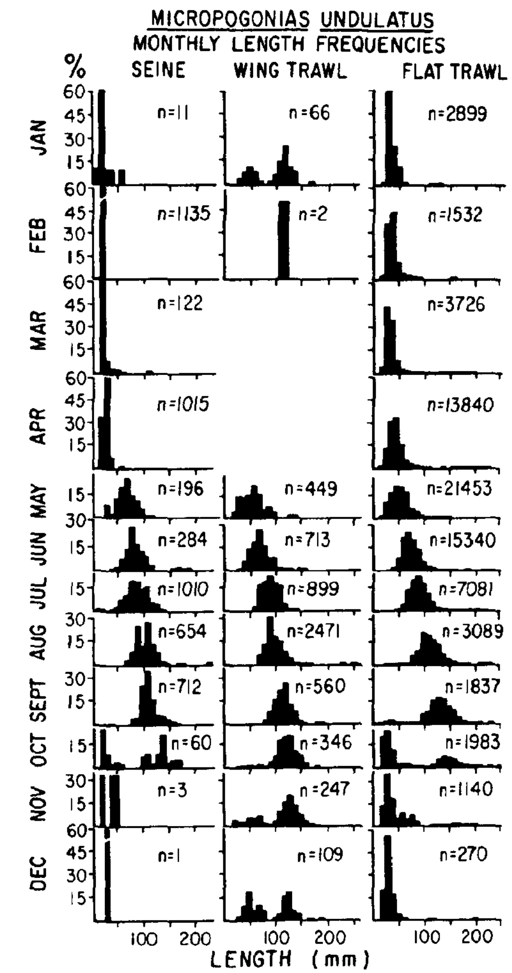

Figure 55. Monthly length frequencies of Micropogonias undulatus.

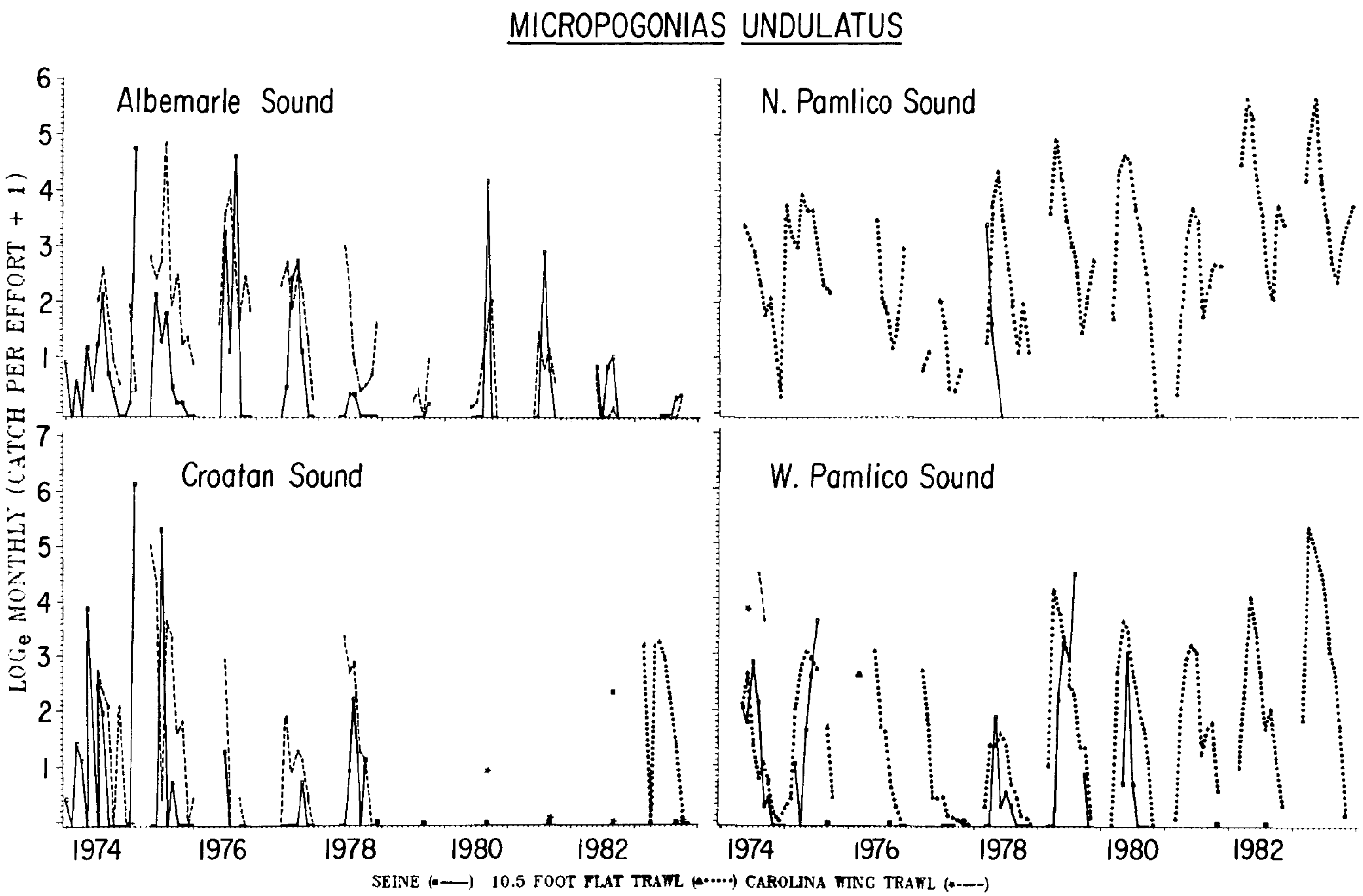

Figure 56. Micropogonias undulatus monthly catch per effort.

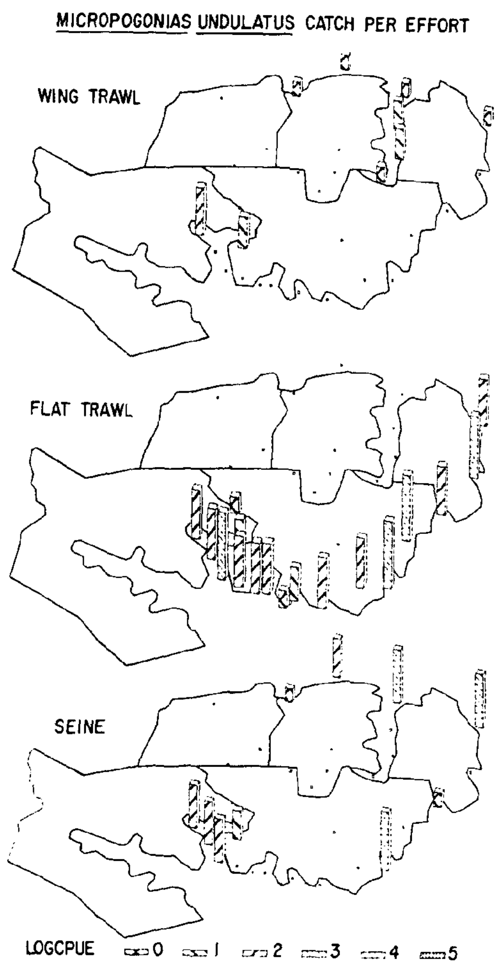

Figure 57. Geographical distribution of _Micropogonias undulatus_ catches.

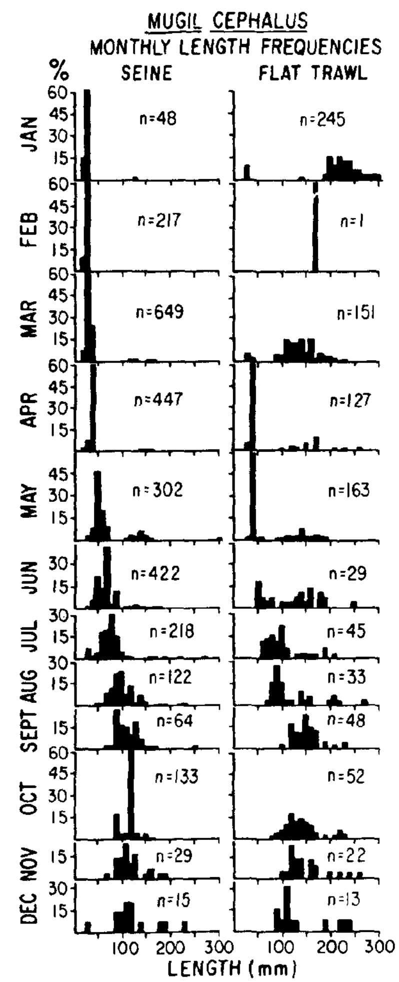

Figure 58. Monthly length frequencies of _Mugil cephalus_.

classes have been identified in the commercial catches (Ross 1982, pers. comm.). North Carolina and peninsula landings peaked in 1979 and 1980 (Appendix A).

Mugil cephalus

The striped mullet is a pelagic migratory species utilizing the shallow estuarine areas for juvenile nurseries and as adult feeding grounds. Spawning occurs offshore in the late fall and early winter (Martin and Drewry 1978) with juveniles first appearing in the nursery areas in January (Figure 58). Juveniles and adults emigrate from the estuary in fall but a few may overwinter. Because striped mullet are pelagic inhabitants of shallow nearshore waters, trawl catches of the species were sporadic and seldom approached the numbers collected with the seine (Figure 59). Striped mullet were collected throughout the peninsula, including Lake Mattamuskeet, but were least abundant in Croatan Sound (Figure 60). Conversely, M. curema, which are usually found in high salinity waters near the inlet, were collected only in Croatan Sound. The M. curema reported in a June 1969 rotenone sample in Lake Mattamuskeet were probably M. cephalus and were analyzed as striped mullet. Lack of seining effort in northern Pamlico Sound precluded comparing the abundance of striped mullet in the two Pamlico Sound basins.

Gill nets and common seines are the major gears that catch mullet. Although most are taken in the Atlantic Ocean, significant quantities are taken in the state's inshore waters.[1] Mullet landings on the peninsula peaked in 1976 (Appendix A) when Albemarle Sound landings reached 200,000 pounds (90,800 kg), nearly a five fold increase over the average for the preceding five years.

The remaining species were less abundant on the peninsula and generally occurred too infrequently to illustrate area specific seasonal patterns (Table 9). However, when combined with information from the literature, some of these species can be profiled.

Spawning by Penaeus duorarum is protracted and recruitment occurs during late May through summer (Hawkins 1982; this study). Pink shrimp CPUE is highest in the fall when the species supports a commercial fishery (Carpenter 1979; Carpenter and Ross 1979; Carpenter 1980;

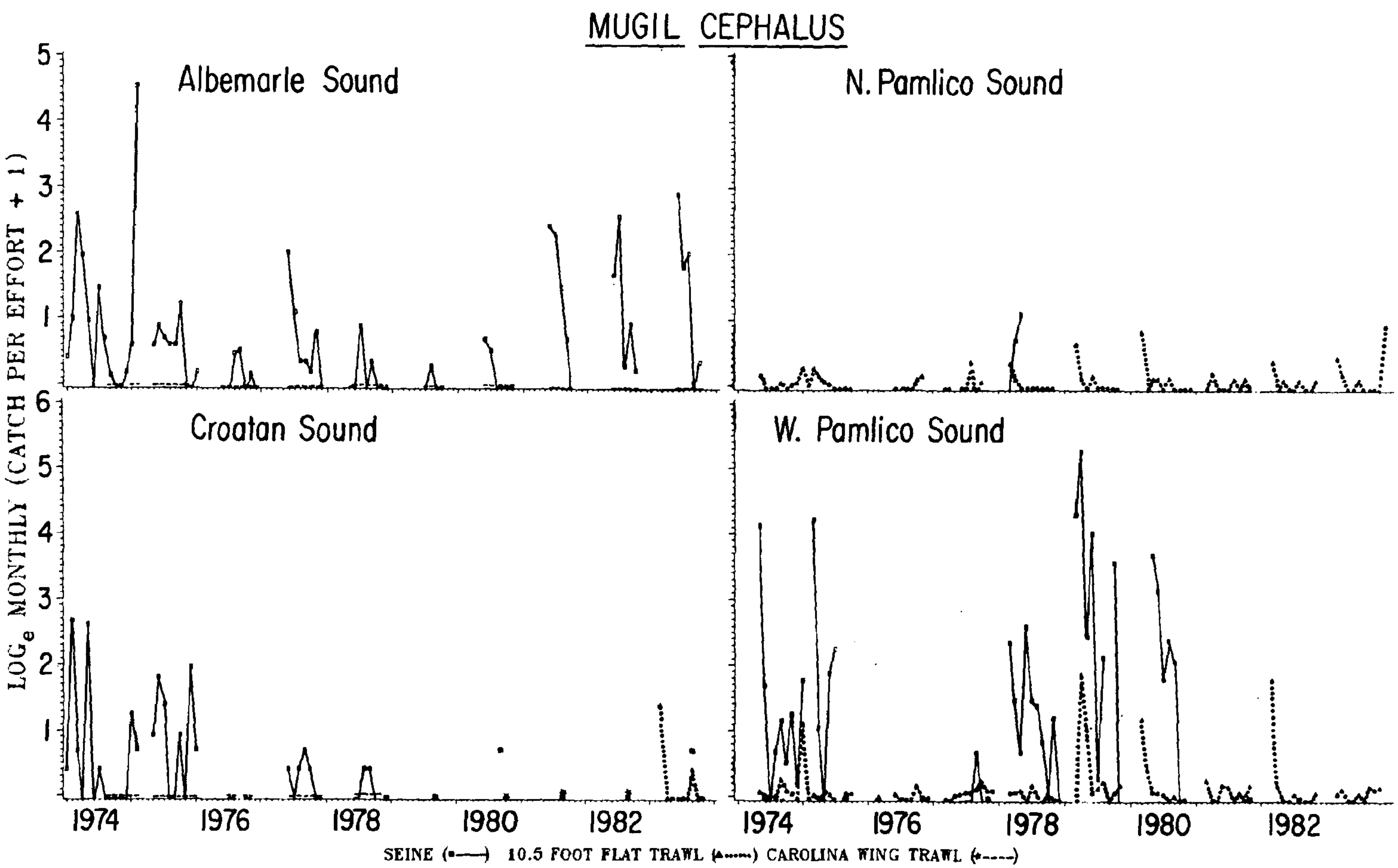

Figure 59. Mugil cephalus monthly catch per effort.

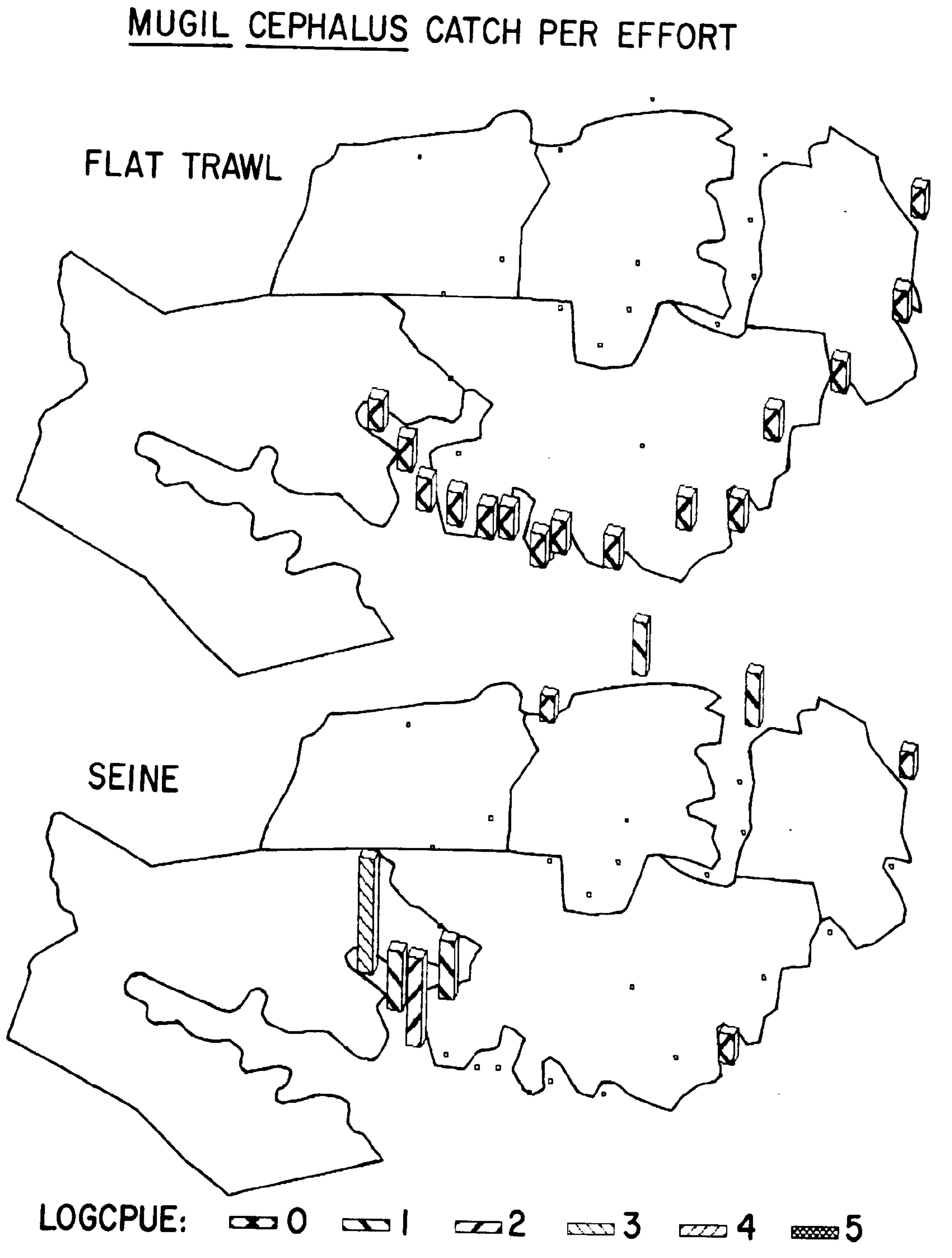

Figure 60. Geographical distribution of *Mugil cephalus* catches.

Table 9. Seine, flat trawl (3.2 m) and wing trawl catch-per-effort for selected species collected in each of the major sounds and lakes of the Pamlico-Albemarle Peninsula. Only bottom towed trawl data are used in calculating trawl CPUE.

	Seine						Flat trawl			Wing trawl			
Species	Albemarle Sound	Croatan Sound	N. Pamlico Sound	W. Pamlico Sound	Lake Mattamuskeet	Pungo Lake	Croatan Sound	N. Pamlico Sound	W. Pamlico Sound	Albemarle Sound	Croatan Sound	W. Pamlico Sound	Lake Phelps
Penaeus duorarum	0	0.04	0	0	0	0	1.29	1.20	0.15	0	0	0	0
Penaeus setiferus	0	0.17	0.05	0	0	0	0.06	2.29	0.16	*	0	0	0
Hybognathus regius	1.66	0	0	0	0	0	0	0	0	0.04	0	0	0
Ictalurus nebulosus	0	0	0	0	0	0	0	*	0.01	0.45	0.20	0	0
Ictalurus punctatus	0.01	0	0	0.01	0.06	0	0	0	0	0.24	0	0	0
Aphredoderus sayanus	0	0	0	0	0	0	0	0	0	0.25	0	0	0
Morone saxatilis	0.54	0.01	0	0.04	0.43	0	0	*	*	0.39	0	0	0
Lepomis gibbosus	0.34	0.12	0	0.03	0.31	0	0.94	0	0.05	0.07	0	0	0.90
Lepomis macrochirus	0.24	0	0	0.19	0.97	0	0.12	0	0.03	0.02	0	0	3.15
Pomoxis nigromaculatus	*	0	0	0	0.37	0	0	0	*	0.77	0	0	0
Perca flavescens	1.29	0.04	0	0.03	1.09	0	0.29	0.01	0.01	0.73	0.03	0	1.99
Cynoscion nebulosus	0.12	0.15	0	0.01	0	0	0	0.34	0.10	0.04	0	0	0
Gobiosoma bosci	0	0.01	0	0.01	0	0	0	0.07	0.17	0	0	0	0
Microgobius thalassinus	0.01	0	0	0	0	0	0.18	0.32	0.30	0	0	0	0
Paralichthys lethostigma	0	0	0	0.05	0	0	0.06	1.11	0.86	0.02	0.03	1.35	0
Trinectes maculatus	0.02	*	0	0.03	0.29	0	0.06	0.29	0.50	0.18	0.03	1.08	0

*less than 0.01 individual per effort

Hawkins 1982; Ross and Carpenter 1983; Ross and Epperly in press, this study). The species may overwinter and depending on winter conditions, support a spring/early summer commercial fishery. Pink shrimp were restricted to Pamlico and Croatan sounds and were much more abundant north of Bluff Shoal. The life history of P. setiferus is similar to that of P. duorarum except that its recruitment period is shorter, beginning in June, and white shrimp do not overwinter appreciably. It is caught commercially in the fall. White shrimp were also most abundant in northern Pamlico Sound.

The southern flounder, Paralichthys lethostigma was the most abundant flatfish collected on the peninsula. Winter-spawned young-of-the-year first recruit in March and reach peak abundance by April or May (Carpenter 1979, Carpenter and Ross 1979; Ross 1980a; Hawkins 1982; Ross and Carpenter 1983; Ross and Epperly in press; this study). Southern flounder were most abundant in Pamlico Sound but the species occurred throughout the peninsula and in Lake Mattamuskeet. It supports a directed pound net fishery off the mouth of Alligator River, in Croatan Sound, and behind Hatteras Island, in addition to the larger Core Sound flounder pound net fishery. Southern flounder are also taken in gill nets, crab trawls, haul seines and to a lesser extent, in the winter trawl fishery (Sholar 1979a, b; DeVries 1980; Ross 1980b, 1982; Ross 1984).[1]

DISCUSSION

The mesohaline waters of Pamlico Sound are quite productive and like the estuaries of other Atlantic and Gulf states (Livingston 1976; Tagatz 1968; Dahlberg 1972; Cain and Dean 1976; Weinstein and Brooks 1983) are seasonally dominated by migratory marine species. Ross and Epperly (in press) analyzed monthly catch data from 51 DMF juvenile stock assessment stations sampled throughout Pamlico and Core sounds in 1981 and 1982, and reported that the stations along the southern perimeter of the Pamlico-Albemarle Peninsula were among the most productive in the Pamlico Sound area. The 51 stations were classified into five well-defined groups based on the distributions and abundances of the 24 most abundant demersal species. Except for tidal influence with its resulting higher salinities, the physicochemical environments of the stations were similar and individual parameters could not be used to separate the station groups. Two station groups, located primarily in Core Sound, were highly influenced by the presence of aquatic vegetation and by high, tidally fluctuating salinities. The remaining three station groups were located in the non-tidal portion of Pamlico Sound and were generally separated in the vicinity of Bluff Shoal corresponding to the northern and western basins. Stations in the western basin were further distinguished by their proximity to the open waters of Pamlico Sound. Those stations farther from open waters were the least productive. Species' abundance and composition were similar between the stations of northern Pamlico Sound and the western Pamlico Sound stations in close proximity to open waters, and both station groups were generally highly productive for most of the commercially important species.

The two Pamlico Sound basins exhibited some differing biological patterns (Ross and Epperly in press; this study). Catches of blue crabs, bay anchovies, croaker, weakfish, spotted seatrout and silver perch were higher in the northern basin, and spot and pinfish catches were greater in western Pamlico Sound. Spot recruitment was earliest in stations north of Bluff Shoal and recruitment of croaker during fall 1974-1983 was significantly higher in the same area. Separate circulatory gyres in the two basins, set up by W-WNW or E-ESE winds (L. J. Pietrafesa pers. comm.), may lead to the divergent biological patterns observed in Pamlico Sound.

Albemarle Sound is the most important spawning and nursery area for anadromous and freshwater species, although other estuaries of the state support populations of these species (Marshall 1976; Hawkins 1980; Judy and Hawkins 1983; Fischer 1983). The spring influx of anadromous fish from the sea is an important component of the sound's fauna, but nekton biomass in the open waters of Albemarle Sound peaks during the winter months in the western portion and is a result of white perch and white catfish migration into the deep waters of the area (Hester and Copeland 1975). Trends in juvenile alosine catch-per-unit effort statistics at the stations located on the peninsula have been similar to trends in indices of juvenile abundance in Albemarle Sound area for both the blueback herring and the alewife (Winslow and Sanderlin 1983).

The inland lakes of the peninsula offer unique habitats for fishes in the region. Although once landlocked, these lakes now have dredged channels allowing immigration of estuarine, anadromous and marine species. The canals leading to Lake Phelps support a population of river herring that differs significantly from the Albemarle Sound and Pamlico Sound populations in that alewives are more abundant than blueback herring; some may enter the lake. The nearshore areas of Lake Phelps support a large population of forage fish, comprised mainly of cyprinids, *Fundulus* spp., *Etheostoma* spp., and juvenile *Morone americana*, *Perca flavescens*, and centrarchids; whereas the mid-lake area is nearly devoid of forage fish (Kornegay and Dineen 1979). The dominant predators in the Lake Phelps system are largemouth bass, white perch, bluegill and pumpkinseed, all of recreational importance. The 1950's stocking of the northern pike and the 1960's and 1970's stocking of striped bass were unsuccessful (Kornegay 1981).

Lake Mattamuskeet underwent a succession of changes after reflooding in 1934 (Holloway 1948). During the post-flooding period of 1936-1947, annual angler catches of the following species peaked in sequence: largemouth bass, black crappie, sunfishes, white perch and carp. Carp and catfish were taken commercially beginning in 1939. In 1949 striped bass and bluegills (accidently) were introduced as a means to control the forage fish populations and enhance sport fishing in the lake. Angler catches increased as a result of continued striped bass and largemouth bass stocking and vegetation and water clarity improved as the forage fish populations declined. Channel catfish have been stocked in recent years in addition to striped bass and largemouth bass (Boaze 1982). Lake Mattamuskeet experiences a regular influx of fauna from Pamlico Sound. Blue crabs, silversides and killifish, are common inhabitants. Striped bass (Geddings 1970) and alewives (Tyus 1971) are seasonally abundant and support recreational fisheries in the lake and surrounding canals, respectively. A portion of the white perch population, one of the most abundant species in the lake, may also migrate out of the lake.

New Lake and Pungo Lake are the smallest lakes on the peninsula. New Lake is not being managed by either a state or federal agency, in part because of its limited accessibility, shallow depths, and low productivity. These factors, combined with the difficulty in sampling the lake because of the many cypress stumps, account for the limited fisheries data from the lake. In contrast to New Lake Fork which Smith and Baker (1965) classified as excellent for sportsfishing, New Lake collections have yielded only the golden shiner and the mosquitofish. It has supported some commercial catfishing (Smith and Baker 1965).

The fauna of Pungo Lake is primarily comprised of freshwater species, but menhaden, white perch and alewives enter the lake. The waters of the Pungo National Wildlife Refuge have been closed to fishing but reproducing populations of certain catfish and centrarchids could support a sport fishery (Boaze 1980). To decrease turbidity and allow stands of aquatic vegetation to be established, Boaze (1980) recommended stocking largemouth bass to feed on the forage fish.

The Pamlico-Albemarle Peninsula is an important nursery area for many species. Even though there has been a suggestion of partitioning in estuarine nurseries through temporal, spatial and trophic segregation (Livingston et al. 1976; Sheridan and Livingston 1979; Weinstein et al. 1980), utilization of the peninsula is usually intense, involving the simultaneous occurrence of a large number of individuals of relatively few species, all with similar trophic and life history patterns. If any one resource were limiting, competition would be predictably high.

Young-of-the-year spot, Atlantic croaker, Atlantic menhaden, pinfish, striped mullet, southern flounder, brown shrimp, alewives and blueback herring recruit in late winter and early spring, whereas young-of-the-year spottail shiners, white perch, white catfish, weakfish, silver perch, atherinids and anchovies recruit in late spring and summer. Atlantic croaker also recruit during the fall in areas north of Bluff Shoal. There was some spatial partitioning among these major species. Alewives, blueback herring, spottail shiners, white perch and white catfish were most abundant in the limnetic and oligohaline reaches of the estuary; the others were more abundant in the mesohaline waters of the peninsula. Some species, such as Atlantic menhaden, striped mullet, atherinids, anchovies and spottail shiners, were pelagic and/or nearshore inhabitants, whereas juvenile weakfish, silver perch, and summer flounder are apparently most abundant in the deeper, more open waters of Pamlico Sound (Powell and Schwartz 1977, Carpenter 1979; Carpenter and Ross 1979; Ross 1980a; Hawkins 1982; Ross and Carpenter 1983). Abundance of some species differed between basins of the Pamlico Sound.

Juvenile fishes in estuaries are trophic generalists (Miller and Dunn 1980) and many fish species including spot and croaker (Woodward 1981), are able to mitigate competition for food resources by decreasing their diet overlap in the absence of their commonly preferred prey (Nilsson 1967). Food, at least in non-tidal Rose Bay (Currin 1984) and the tidal Newport River area grass beds (Adams 1976; Thayer et al. 1975), is usually abundant.

The commercial fishing industry depends on estuarine dependent species and their successful production in the nursery areas. Although estuarine waters in adjacent states are also very productive (Tagatz 1968; Hackney et al. 1976; Cain and Dean 1976; Chao and Musick 1977; de Sylva et al. 1962), commercially exploitable concentrations of large adults of the most abundant fishes in these systems occur between Sandy Hook, N.J. and Cape Fear, N.C. (Street and McClees 1981; Wilk 1981). The degree of latitudinal mixing is not known. In North Carolina, when Atlantic menhaden landings are excluded, most of the commercial and recreational landings are taken from inshore waters (DeVries 1980; Street and McClees 1981); even in Dare County, the base of the offshore winter trawl fishery, 50% of the landings, are taken from inshore waters[1]. Landings by gear are given in Appendix B.

Long haul seines, crab pots, trawls, pound nets and dredges account for most of the inshore waters' landings.[1] Eel pots are set in the low salinity (oligohaline) waters of the peninsula during the spring and fall (Figure 61) (S. E. Winslow and J. H. Hawkins pers. comm.), and hook and line catches occur throughout the peninsula. White perch, largemouth bass and other centrarchids, catfishes, and striped bass are the most common species taken by hook and line in Albemarle Sound (Mullis and Guier 1981). Sciaenids, bluefish, mackerels and flounder are the most common salt water species caught by hook and line in North Carolina[2].

Shellfish are taken from Croatan and Pamlico Sounds with rakes, tongs, dredges and infrequently by clam trawls (Figure 62). Most (>90%) of the sounds' oyster catches are landed in the peninsula counties,[1] but clams are infrequently landed in those same counties (Appendix A).

Long haul seines are used throughout Croatan Sound and Pamlico Sound north of Wysocking Bay, including the deep waters north of Long Shoal (Figure 61). They are also used in the shallow waters west of Wysocking Bay in areas where, by regulation[3], crab pots cannot be set. The fishery operates during April through October and spot, Atlantic croaker, Atlantic menhaden, weakfish, pinfish and bluefish are the species most commonly captured (Sholar 1979a,b; DeVries 1980; Ross 1980b, 1982; Ross and Carpenter 1983; Ross 1984). Seines are also hauled during the late winter, early spring, and fall in western Albemarle Sound and during the winter in eastern Albemarle Sound where they are used to capture catfish and white perch (S. E. Winslow pers. comm.) and in Lake Mattamuskeet where they are used to capture forage fish.

More than 50% of the crabs landed in North Carolina are taken from the Pamlico and Croatan sounds areas.[1] Crab pots are the major gear used and are set during spring through fall throughout eastern Albemarle Sound, Croatan Sound and Pamlico Sound, except where prohibited (Figure 61). In Croatan and Pamlico sounds crab trawling is another source of crabs (Figure 62), but this method accounted for less than 25% of the area's total crab landings during the last three years.[1] Crab trawling occurs throughout the year but crabs are generally caught in the spring through fall. Southern flounder catches in the crab trawls are significant and rank second to pound net catches for this species.[1]

Shrimp trawling occurs throughout Croatan and Pamlico sounds. Activity in the Pungo River is usually below Durants Point (Figure 62) (J. H. Hawkins pers. comm.). Approximately 70% of the Pamlico Sound shrimp landings are summer caught brown shrimp (N.C. Div. Mar. Fish. 1983). Depending on the year, fall catches of pink and white shrimps and spring catches of pink shrimp may be significant.

The majority of pound nets set in Pamlico Sound along the Pamlico-Albemarle Peninsula are bait pounds and are generally fished in the fall (Figure 62) (J. H. Hawkins pers. comm.). In the past only a

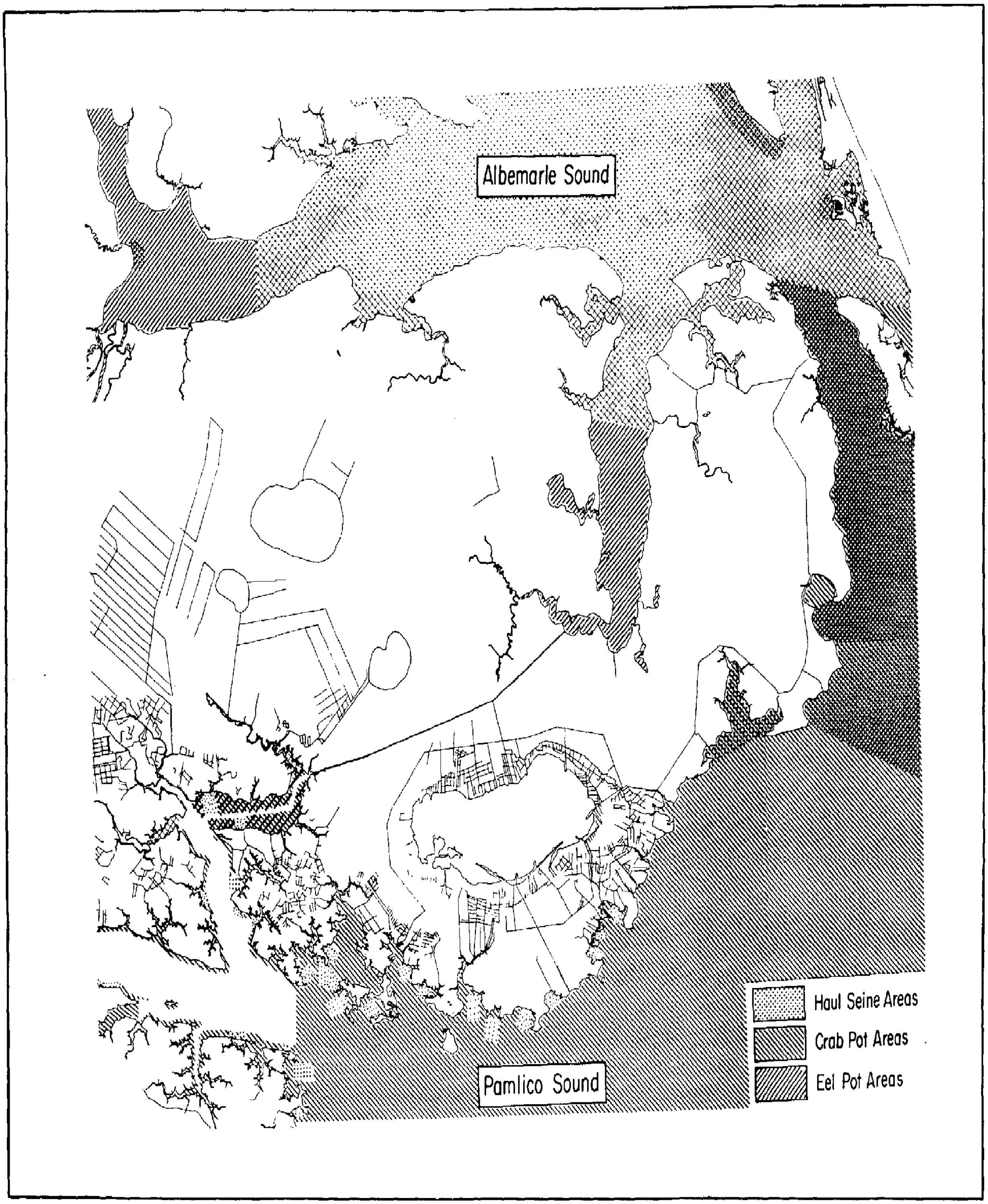

Figure 61. Haul seine, crab pot and eel pot fishing areas in the vicinity of the Pamlico-Albemarle Peninsula.

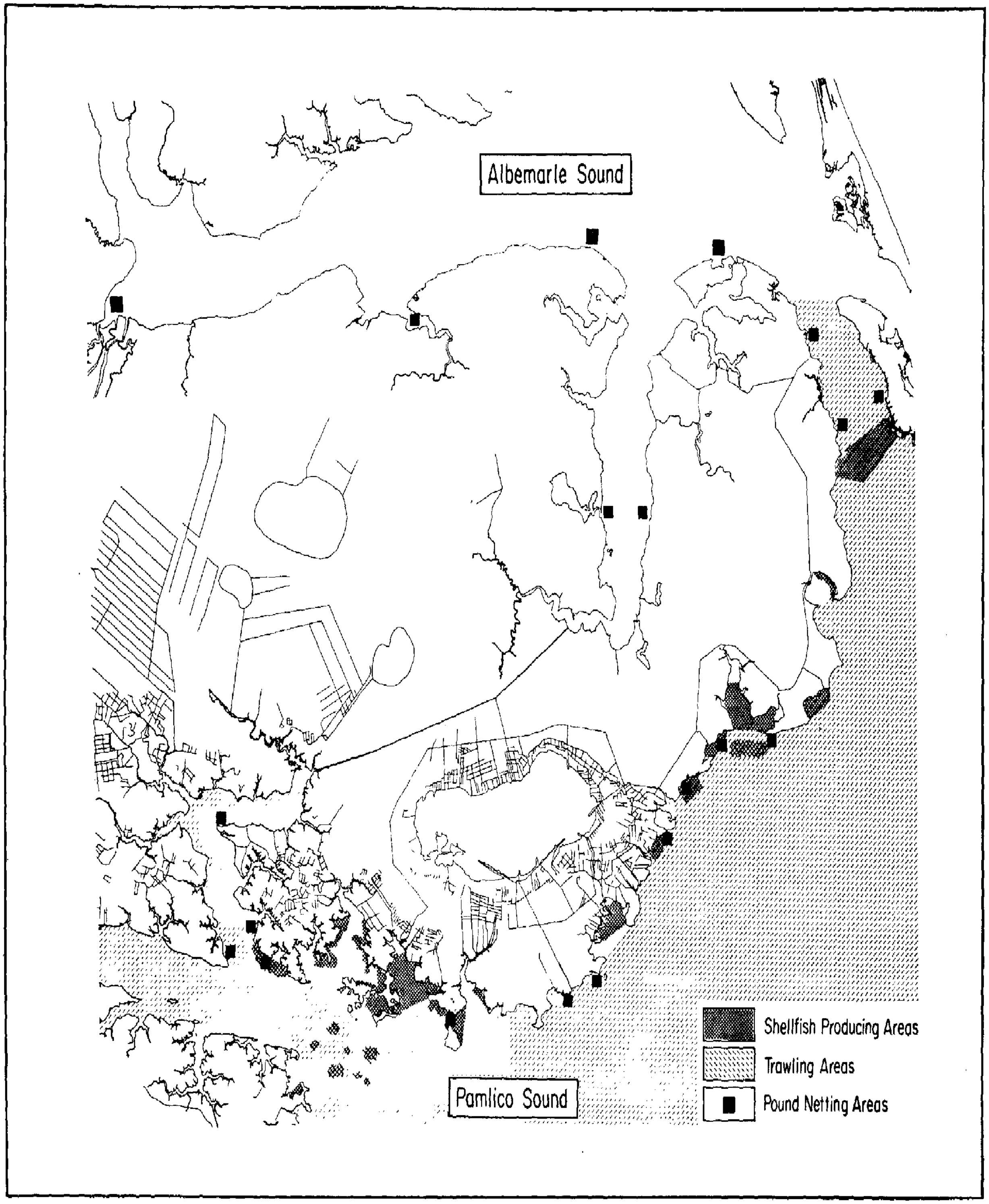

Figure 62. Shellfish, trawling and pound net fishing areas in the vicinity of the Pamlico-Albemarle Peninsula.

few have been set for foodfish, mainly for sciaenids and southern flounder. Pound nets are set for in the fall in Croatan Sound (J. L. Ross pers. comm.) and at the mouth of Alligator River for flounder, and in the late winter and spring for anadromous fish in Croatan and Albemarle sounds. (S. E. Winslow pers. comm.)

Gill nets are set throughout the bays, tributaries and open waters of Croatan, Pamlico, and Albemarle sounds (J. H. Hawkins, S. E. Winslow and J. L. Ross pers. comm.). Flounder (mostly southern flounder) and sciaenids are taken during spring through fall in Croatan and Pamlico sounds. Directed fisheries for flounder occur in the spring and fall in Abel Bay, Spencer Bay, Rose Bay, Pungo River, and in the fall in Croatan Sound and eastern Albemarle Sound. White perch, catfish and striped bass are caught in Albemarle Sound throughout the year. Mullet are sought in the fall and winter in the Pungo River and eastern Albemarle Sound and gill nets are set for anadromous fish in the late winter and early spring throughout the waters of the peninsula.

Albemarle Sound has traditionally provided most of North Carolina's anadromous (Winslow and Sanderlin 1983) and freshwater fish landings (Harriss 1982). Landings of these species have been decreasing, probably due to a combination of overfishing and deteriorating water quality in the western portion of Albemarle Sound (Mullis and Guier 1981; Street 1984). Catfish, white perch, and anadromous fish landings in the five counties of the Pamlico-Albemarle Peninsula have followed the falling trend (Appendix A), except that peninsula landings of alewife and blueback herring have not mirrored the decline. However, access and fishing pressure along the southern portion of Albemarle Sound are limited, and catches there may not be indicative of the river herrings' population sizes in the area (Johnson et al. 1977).

POTENTIAL IMPACTS

Estuaries are very dynamic systems, and are comparatively productive (Ketchum 1967; Odum and Heald 1975; Adams 1976). They have been colonized by several groups of organisms that have evolved efficient adaptive and compensatory strategies to withstand the potential stress of the environment (Kinne 1967; Potts and Parry 1964).

Many factors such as age, nutritional, reproductive, and acclimation state and genetics must be considered when evaluating an organism's response to stress (Costlow et al. 1960; Levinton 1980) and seldom can one stress factor be evaluated without considering its interaction with other factors (Livingston 1979). Effects of stress can be acute (lethal) or sublethal, but a sublethal effect can be critical to the survival of a population even though it is not fatal to the organism. Because we know little about the natural variability and trophic dynamics in coastal ecosystems or the role of advective processes and abiotic factors in the distribution and abundance of estuarine biota, it may be difficult to detect changes in estuarine communities and attribute any changes to specific sources of stress. However, there are some data available to address certain issues concerned with the potential impacts of land development on fisheries.

The amount and seasonality of dissolved solids is critical to the functioning of the estuarine nursery areas. Land development in the coastal region alters the hydrology of an area and while the increase in annual outflow may be slight, peak runoff occurs sooner and is much higher on developed lands than on undeveloped lands (Skaggs et al. 1980). Therefore, the salinities of the receiving waters are less stable. Rapidly fluctuating salinities are stressful for many estuarine organisms (Hochachka 1965; Hoar 1966; Day 1967; Livingstone et al. 1979) and some, like the spot and croaker, exhibit strong avoidance reactions to fluctuating salinities (Gerry 1981). Pate and Jones (1981) reported catches of spot, croaker, southern flounder, blue crab and brown shrimp to be significantly lower at stations exhibiting the most unstable salinity patterns. High salinities as a result of decreased freshwater inflow (see Cross and Williams 1981 for a review) have been associated with complex changes in estuarine nursery areas and their decreased productivity (Benson 1981). Conversely, the lowest salinity areas of the estuary are typically less diverse and less productive than the relatively higher salinity areas (Gunter 1977). A salt marsh's resiliency is limited and sustained levels of increased runoff may leach sediment salts, causing permanent changes in the flora and fauna of the coastal wetlands (Zedler 1983). Decreased inland water levels as a result of drainage for development could decrease the area of freshwater fisheries habitat. Alteration of natural ambient water temperatures due to heated effluents is also a concern because the altered temperature regime could potentially impact biological cycles which may be keyed on temperature, such as spawning or emigration.

Drainage waters from developed lands have a higher sediment load than waters draining undeveloped lands (Kirby-Smith and Barber 1979; Skaggs et al. 1980). A certain amount of sediment is necessary to nourish estuarine communities but too much may be detrimental. Although small when compared to the Piedmont area, the potential annual sediment loss of 5.6×10^4 kg/m^2 (¼ ton/acre) estimated for an area of mainland Dare County (U.S. Army Corps of Engineers 1982) may be significant when distributed into the receiving waters of the peninsula. Decreased light levels as a result of the increased turbidity can significantly impact primary production, decreasing oxygen production (Russell-Hunter 1970). Elevated BOD levels due to increased microbial activity on the suspended particles could lead to oxygen stress in the estuarine waters. High levels of suspended sediment have been demonstrated to reduce the survival of fish eggs and larvae (Auld and Schubel 1978) and interfere with the reproduction of sessile shellfish (Galstaff 1964). Buried oyster beds are a testimony to the effect of high depositional rates on a benthic community (Galstoff 1964). Coliform bacteria, which are used as indicator organisms for the presence of animal-borne disease, are also more abundant in runoff waters from developed lands (Skaggs et al. 1980).

The largest peat deposits in North Carolina are found on the Pamlico-Albemarle Peninsula and represent the accumulation of organic matter in the pocosins (Otte and Ingram 1980). The peat naturally contains a number of heavy metals (Environmental Science and Engineering, Inc. 1982a) which may be leached from the land during development or in effluent as a result of peat processing. Some metals such as copper, zinc and iron are used by aquatic organisms as enzyme cofactors but may be a toxicant when found in excess (Moore and Ramamoorthy 1984). Heavy metal concentrations above threshold levels are known to be toxic to aquatic life (Ruivo 1972; Vernberg and Vernberg 1974; Lockwood 1976; Giam 1977; Vernberg et al. 1977; Cole 1979) and the toxicity is frequently taxa specific (Moore and Ramamoorthy 1984). Most effects are tested in laboratory toxicity tests but chronic, sublethal concentrations of pollutants may have long-term effects which are difficult to evaluate or predict from laboratory toxicity tests (McIntyre and Mills 1975). Sublethal effects in marine organisms include inhibition of enzyme synthesis; decreased reproductive potential, growth, sensory abilities, and osmoregulation; and behavioral changes (Moore and Ramamoorthy 1984; Cole 1979). Frequently metals have synergistic effects on each other (Moore and Ramamoorthy 1984; Ramamoorthy and Blumhagen 1984). The chemical form of a metal is very important but speciation of trace metals can be highly variable and is dependent on metal concentration and environmental parameters such as organic matter, salinity and pH (Engel et al. 1981). The toxicities of these metals are a function of such parameters as the metal concentration and its forms, temperature, dissolved oxygen and exposure time (Moore and Ramamoorthy 1984). For example, mercury is most toxic when the mercuric form binds with a methyl group from a donor molecule, which is a commonly occurring biological end product in many aquatic systems. Under reducing conditions, the concentration of the mercuric form is relatively depressed and when the temperature is low or the concentration of organic matter is high, the same concentration of methyl mercury is not as toxic as when temperatures are higher or organic matter concentrations are lower (Moore and Ramamoorthy 1984); Ramamoorthy and Blumhagen 1984). Some metals such as mercury and copper accumulate through the food chain whereas bioaccumulation of metals such as lead, chromium and nickel is undocumented.

Currently the major land uses of the peninsula are for agriculture and forestry (North Carolina Office of State Budget and Management 1981); agriculture has been proposed as reclamation for peat-mined lands. Nutrient loading in estuarine waters of North Carolina has increased at least one order of magnitude over that of predevelopment conditions (Kirby-Smith and Barber 1979), and has been implicated in the eutrophication of coastal waters (Paerl 1982) and in the promotion of <u>Aeromonas</u>, a bacteria causing red sore disease in fishes (Esch and Hazen 1980). Pesticides and organochemicals are used in forestry and agriculture, and may pose a threat to the estuarine organisms because of their ability to kill or stress the organisms and because they may persist in the environment (Eisler 1972). Toxicity may be acute or sublethal and include such effects as death; decreased growth and reproductive potential; and behavior changes (Eisler 1972; Mitrovic 1972). Bioaccumulation may be high, reaching a factor of 70,000 for some shellfish (Butler 1966).

The fishes of the Pamlico-Albemarle Peninsula could be affected by land development in the area, but because environmental degradation is usually insidious and cumulative (Odum 1970), impacts are difficult to predict. It is assumed that all effects of such degradation are deleterious, but not demonstrable for relatively low exposures.

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FOOTNOTES

1. North Carolina general canvas data from the N.C. Division of Marine Fisheries and the National Marine Fisheries Service.

2. National Marine Fisheries Service marine recreational fishery statistics surveys, 1979-1982, unpubl. data.

3. N.C. Department of Natural Resources and Community Development, Division of Marine Fisheries. North Carolina Fisheries Regulations for Coastal Waters 1984. Regulation 3B.0504.

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Appendix A. North Carolina commercial marine fisheries landings (in thousands of pounds) by species 1962-1983 for Beaufort, Dare, Hyde, Tyrrell, and Washington counties. Landings data do not include menhaden or thread herring and county data prior to 1978 do not include unclassified non-edible landings. North Carolina general canvas data from the N.C. Division of Marine Fisheries and the National Marine Fisheries Service.

	Species															
Year	Alewife and blueback herring	Amberjacks	Angelfishes	Bass striped	Bluefish	Bonito, Atlantic	Butterfishes	Carp, common	Catfishes	Cobia	Cod, Atlantic	Croaker, Atlantic	Cutlassfish, Atlantic	Dolphins	Drum, black	Drum, red
1962	636.5			407.6	244.2		77.0	30.3	698.4	11.2		131.7			54.5	17.8
1963	354.6			327.8	265.6		37.5	19.5	618.8	10.3		63.5			9.6	17.3
1964	528.1			330.6	72.4		61.3	23.1	384.2	5.4		82.2			16.4	12.9
1965	239.6			228.1	232.0		93.9	18.6	421.7	6.6		116.4			71.0	14.6
1966	274.4			274.9	207.2		176.7	17.4	651.6	5.6		113.8			20.1	11.1
1967	253.4			1,260.3	230.1		56.0	95.1	683.0	7.5		117.7			15.8	3.9
1968	599.9			1,522.9	264.9		38.0	22.5	557.2	4.2		50.0			9.8	
1969	270.3			1,195.9	382.2		29.2	15.6	530.1	5.9		25.6			1.8	0.6
1970	303.0			1,926.6	157.2		94.3	2.4	572.2	3.8		82.6			4.0	1.2
1971	593.3			1,258.0	245.8		39.9	10.4	629.5	9.0		141.5			10.6	5.3
1972	286.0			1,104.5	339.7		10.2	8.0	633.9	2.6		166.4			17.5	21.9
1973	477.2			1,468.9	840.7		5.9	2.5	294.5	1.5		833.0			9.1	35.6
1974	189.9			665.3	563.4		28.6	5.6	421.7	0.5		1,546.3			14.1	68.6
1975	494.1			805.6	869.3		19.8	62.7	436.0	1.5		2,428.0			6.5	80.2
1976	355.9			729.9	607.1		31.1	0.8	391.4	1.0		7,264.0			3.3	59.7
1977	379.0			379.0	927.9		20.1	12.0	703.0	0.1		6,804.4			0.4	5.2
1978**	477.5			380.8	836.1		66.3	29.6	349.7	1.5		6,470.7		2.0	20.9	2.0
1979**	379.3			237.2	1,465.9		125.7	26.5	311.6	0.8	0.1	10,216.5			44.2	24.6
1980**	464.4	5.3		214.2	3,019.3	17.2	108.8	62.3	349.3	3.7	0.6	11,351.5		2.9	14.2	42.4
1981**	1,029.0	5.6		172.2	4,355.2	3.7	228.1	64.1	330.4	2.3	0.7	8,010.1		2.3	74.5	49.6
1982**	1,188.2	2.5		188.3	2,798.0	28.5	153.3	63.2	244.9	3.5	1.8	7,474.8		5.8	22.5	5.1
1983**	876.0	2.9	0.1	189.0	3,105.3	11.0	40.0	77.8	236.9	0.4	1.9	5,127.7	19.0	6.6	1.0	46.8

Appendix A. (continued)

Year	Species: Eel, American	Flounders	Goosefish	Groupers	Grunts	Haddock	Hakes	Harvestfish	Jack, crevalle	Kingfishes	Mackerel, Atlantic	Mackerel, king	Mackerel, Spanish	Marlin, blue	Mullets	Perch, sand
1962	9.9	711.8						14.1		195.1	20.3	1.7	41.6		386.7	
1963	5.1	1,050.9					0.5	12.5		68.8	1.4	2.5	53.9		419.6	4.0
1964	16.6	875.7						5.9		63.7		2.5	33.5		133.0	3.3
1965	20.2	1,496.1						85.1		132.3		5.9	46.3		115.2	0.4
1966	15.2	1,863.0						64.5		138.3	12.5	11.5	28.3		98.3	
1967	8.2	2,005.8	5.6					122.2		80.1	0.5	5.5	18.6		74.2	
1968	3.8	1,102.4	4.0					63.4		112.7		1.4	33.7		116.5	0.1
1969	4.1	1,168.6						17.3		154.4		6.1	69.1		122.4	
1970	5.0	1,483.6						18.1		206.0		5.2	27.3		106.2	
1971	113.0	1,944.1					285.5	18.8		113.4		5.0	19.9		118.0	4.4
1972	45.9	1,656.2					1.5	11.7		103.4		0.7	2.1		223.0	0.5
1973	98.6	2,345.8						3.6		67.0		4.1	3.3		168.3	
1974	344.7	5,084.0					2.3	5.5		72.8		7.6	3.9		525.6	0.8
1975	209.4	5,877.9						1.0		74.1	58.3	65.4	16.1		539.0	1.8
1976	450.0	4,792.7						12.9		54.4	440.3	130.9	13.1		737.2	0.2
1977	194.6	5,002.1					13.5	16.8		82.8	266.1	228.4	14.3		410.4	
1978**	412.8	5,761.0	80.6	0.1			0.6	2.5		36.9	22.6	115.0	1.3		185.1	
1979**	554.9	8,566.9	250.9				817.0	7.2		129.8	27.5	285.8	9.5		301.2	
1980**	401.3	8,045.7	280.1	6.3	0.5		678.4	36.4		61.4	1.8	514.7	38.0		270.8	
1981**	151.1	4,064.0	138.8	7.7	2.2		3,131.6	16.1		28.3	145.1	524.7	19.0		283.9	
1982**	279.3	3,166.2	92.9	70.0	0.6	*	622.4	129.7		89.3	70.5	903.5	94.5	0.2	151.8	
1983**	180.5	4,006.4	45.3	25.3	0.2		28.1	85.2	5.4	83.8	*	565.1	20.0		252.4	

Appendix A. (continued)

Year	Species																
	Perch white	Perch yellow	Permit	Pigfish	Pinfish	Pollock	Pompano, Florida	Porgies	Puffers	Sea basses	Seatrout, spotted	Shad, American	Shad, gizzard	Shad, hickory	Sharks	Sharks, dogfish	Sheepshead
1962	97.4	11.1		59.1			2.6	105.2	45.1	302.4	58.6	412.0		71.7	0.3		1.9
1963	64.8	17.2		21.5			3.9	45.5	15.4	203.7	86.6	487.6		100.6	0.8		1.2
1964	95.9	23.6		18.5			0.5	125.7	11.0	121.9	56.9	322.5		34.0			0.7
1965	61.9	13.2		13.6			2.1	797.3	4.8	274.2	71.5	428.1		59.3	0.5		1.7
1966	54.5	15.2		20.2			13.5	944.3	1.3	252.4	27.4	420.2		29.1	0.7		1.6
1967	98.9	17.0		42.6			13.8	118.8	21.1	324.3	49.9	442.8		56.3	0.9		2.1
1968	75.6	13.8		27.3			2.1	53.8	1.8	269.8	25.0	465.2		38.7	0.4		0.5
1969	63.9	10.7		37.1			2.1	73.6	3.4	220.9	48.9	345.9		53.5			0.1
1970	56.7	15.9		45.6			0.7	51.6	2.1	269.0	133.1	499.6		15.0			0.7
1971	100.8	9.3		69.4			0.7	85.6	4.7	103.1	128.1	389.7		21.7	2.0		1.2
1972	74.3	18.2		25.7			1.8	32.5	30.6	71.8	124.6	226.0		33.5			0.4
1973	38.3	3.0		16.4			5.4	10.8		95.8	196.7	134.9		25.9			0.6
1974	110.9	12.6		3.8			1.3	31.5		100.9	221.6	178.9		26.9			3.1
1975	66.2	2.3		3.6			4.1	106.5		453.4	227.4	121.6		13.5			1.1
1976	51.3	10.6		3.1			4.0	203.7		294.4	234.5	94.0		5.9			8.3
1977	96.2	35.5		0.2			0.9	114.7		1,076.3	67.1	52.6		11.8			1.4
1978**	143.8	9.7		0.6			0.2	1,054.1	3.5	988.2	62.2	221.7	31.0	8.6	1.6		3.5
1979**	124.4	1.9					0.6	1,284.2	2.8	709.7	39.5	122.4	2.4	20.3	0.7		6.6
1980**	57.9	2.5		2.0	0.3		0.7	1,293.3	1 0.4	638.0	43.1	63.3	0.3	26.8	6.2	2.3	14.9
1981**	146.3	5.2		6.6			3.7	1,370.9	2.9	603.9	46.6	186.4	46.7	61.9	38.2	4.3	3.0
1982**	238.3	3.5		14.6		0.9	12.5	1,506.2	8.8	415.4	44.7	197.6	79.2	11.9	23.9	6.4	8.7
1983**	181.9	4.1	*	15.5		2.5	1.5	664.6	1.1	184.3	80.3	180.3	35.5	30.9	46.1	*	13.3

Appendix A. (continued)

Year	Species															
	Snappers	Spadefish, Atlantic	Spot	Sturgeons	Swordfish	Tautog	Tilefishes	Triggerfishes	Tripletail	Tunas	Tuna, bigeye	Tuna, blackfin	Tuna, bluefin	Tuna, little	Tuna, yellowfin	Wahoo
1962		2.5	396.9	13.4			0.2									
1963		5.5	153.5	14.8	1.2		0.1									
1964		2.1	312.2	1.6	440.7								13.0			
1965		0.2	217.2	4.3	520.2								59.5			
1966			263.7	3.5	76.9								13.7			
1967			641.4	7.9												
1968		1.6	398.9	3.6												
1969		0.3	239.7	14.3												
1970		2.0	370.3	37.6												
1971		3.5	283.7	19.7												
1972		0.3	498.1	26.1												
1973		1.4	523.7	25.1												
1974		1.6	503.3	28.7										12.1		
1975		8.2	759.	20.5										1.3		
1976		7.4	565.2	0.5										1.3		
1977		3.0	510.3	9.4												
1978**	10.5	0.1	850.1	16.3	18.0	0.1	18.2	0.1	*	*				2.5	2.1	2.0
1979**			1,355.8	26.3			2.5			0.3			0.8		17.5	0.1
1980**	29.1	0.2	1,815.2	15.6	140.6	0.4	0.2	1.6	0.2	3.7			0.3	87.0	4.1	1.5
1981**	27.4	13.7	1,099.3	13.0	65.8		1.0	2.1		1.4				16.2	4.8	0.5
1982**	43.3	4.3	1,477.6	9.5	36.3	0.6	5.3	2.0	0.1	0.1		0.7	2.2	9.5	29.3	2.2
1983**	10.1	1.3	515.9	5.8	7.8	0.3	10.3	1.1		13.2	1.9	1.3		52.5	50.0	2.4

Appendix A. (continued)

	Species										
Year	Weakfish	Unclassified fish for food	Unclassified fish for industrial	Clams, hard (meats)	Clam, Rangia	Clam, surf	Crab, blue, hard	Crab, blue, soft or peeler	Crab, horseshoe	Lobster, American	Octopus
1962	429.1			4.5			6,798.0	11.4			
1963	279.2			1.0			10,079.9	12.4			
1964	127.1			2.2			14,298.6	7.1			
1965	196.9			1.5			13,595.6	28.3			
1966	175.8			1.3			12,369.8	27.1			
1967	181.2			0.8	0.6		8,925.8	24.5		2.5	
1968	126.9			1.2	9.1		12,922.0	27.8		29.9	
1969	131.7			0.4			14,859.2	28.5		8.9	
1970	160.8						12,851.6	16.1		1.4	
1971	296.6						9,256.6	16.6		0.3	
1972	1,220.3						8,147.4	22.0			
1973	1,589.2						7,999.2	32.4		1.6	
1974	1,384.3						8,199.8	15.9			
1975	3,231.7						6,473.6	11.9			
1976	3,668.4					20.4	6,887.7	11.3			
1977	3,867.5						7,503.9	10.8			
1978**	4,013.7		1,875.1				11,261.7	28.1		0.1	
1979**	6,562.9	0.4	1.320.7				13,818.6	27.3			
1980**	10,183.9		1,743.5				17,954.3	37.3		0.9	
1981**	9,305.8		3,231.8				18,831.5	24.1		*	
1982**	5,562.0		2,244.5	3.3			18,879.2	67.2	2.2		
1983**	4,884.7		3.428.3	7.4			16,664.6	28.7	1.7		0.3

Appendix A. (continued)

Year	Species							
	Oysters	Scallop, bay (meats)	Scallop, sea (meats)	Shrimps (heads on)	Squids	Turtle snapper	Whelks (meats)	Unclassified shellfish
1962	278.6			1,060.0	5.6	5.2		
1963	84.4			595.5	15.7	8.5		
1964	191.3			687.7	11.9	9.0		
1965	154.3		72.1	719.0	5.7	10.0		
1966	129.0			792.6	9.0	6.8		
1967	100.4			740.6	19.7	10.2		
1968	70.2	0.6	41.7	826.3	20.6	13.8		
1969	101.1		12.6	1,792.2	17.6	11.3		
1970	149.7	1.4		1,082.3	15.5	17.9		
1971	201.5			1,601.6	5.4	15.0		
1972	175.2			761.1	9.9	5.8		
1973	311.5			598.9	21.0	2.5		
1974	283.4		*	1,428.8	37.6	13.7		
1975	215.2			494.7	40.2	2.3		
1976	124.6		736.7	1,273.1	10.9	3.3		
1977	198.5	155.4	155.0	1,405.9	16.1	1.9		
1978**	91.8		624.0	418.9	116.1	11.7	32.0	708.6
1979**	241.8			265.1	486.4	2.4	31.2	1,093.5
1980**	323.3		578.7	1,647.2	254.3	12.1	24.5	
1981**	185.3		96.5	322.7	229.7	0.6	6.4	
1982**	241.8		0.3	1,077.7	108.0	0.7	3.8	
1983**	375.1		13.8	577.0	257.8	0.2	4.5	

*Denotes less than 100 pounds landed.

**Preliminary landings. Data subject to revision in the Fishery Statistics of the U.S.

Appendix B. North Carolina commercial marine fisheries landings (in thousands of pounds and dollars) by gear 1962 - 1983 for Beaufort, Dare, Hyde, Tyrrell, and Washington counties. Landings data do not include menhaden or thread herring and county data prior to 1978 do not include unclassified non-edible landings. North Carolina general canvas data from the N.C. Division of Marine Fisheries and the National Marine Fisheries Service.

Gears	1962		1963		1964		1965		1966		1967		1968		1969	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
Haul seines	1,155.8	125.6	856.6	102.3	700.6	86.4	770.0	88.5	818.6	77.8	1,667.4	149.1	1,507.4	215.6	1,565.2	232.6
Purse seines	40.0	6.4	10.0	1.6							52.2	9.7	25.6	5.6	187.8	36.0
Trawls																
scallop	3,922.2	688.8	4,074.3	498.9												
crab					3,507.1	150.8	4,499.2	262.8	6,095.7	285.8	5,292.7	266.3	5,407.6	540.6	4,796.8	477.7
shrimp					1,411.2	295.0	1,418.0	275.7	1,131.0	419.6	931.2	309.7	1,530.8	545.0	2,424.0	1,152.8
fish					1,325.9	197.5	2,858.4	443.0	2,965.1	383.0	2,382.4	434.9	1,316.1	294.3	1,413.0	318.6
lobster															8.9	6.4
Pound nets	951.1	109.0	809.7	116.8	767.4	75.7	675.0	73.3	974.8	131.6	758.9	97.1	891.0	85.4	494.5	91.3
Fyke and hoop nets	50.8	4.0	16.2	1.4	8.6	0.8			73.2	10.7	30.0	4.0	13.7	2.0	15.1	2.1
Pots and traps	3,207.4	150.2	6,346.5	341.1	6,892.4	409.4	4,407.5	268.0	4,400.0	236.2	2,377.0	144.8	5,043.1	467.4	7,618.3	723.1
Gill nets																
anchor, set or stake	983.3	99.7	883.7	98.9	665.3	70.0	700.2	92.3	834.0	111.1	1,708.6	233.1	1,797.2	301.5	1,189.4	199.4
drift	44.5	5.3	18.7	777.0	10.3	413.0	6.7	0.2			2.2	0.4	40.5	1.4	4.0	0.5
runaround	171.2	18.4	185.0	18.2	117.3	15.5	144.0	13.1			43.0	5.2	24.5	2.3	5.4	0.5
Lines																
hand			4.0	720.0	2.7	486.0	1.5	0.2	7.7	1.2	15.5	2.3	17.9	2.7	22.6	3.4
troll									15.5	2.6	5.5	1.3	1.4	0.3	6.1	1.5
longline			1.2	648.0	453.7	213.0	580.2	292.6	168.9	52.8	96.1	14.9	80.3	12.0	75.0	11.2
trot	3,041.3	121.7	2,346.9	122.8	3,510.5	188.9	4,368.7	246.3	2,019.2	93.0	1,416.4	69.6	2,080.7	192.7	2,053.3	189.4
Dip nets													73.5	1.4	83.3	3.9
Spears	12.5	2.3	10.0	1.6							2.0	0.4	1.5	0.5	0.3	0.1
Dredges	279.2	189.7	85.4	59.5	193.5	131.0	228.0	144.6	115.5	63.6	92.9	60.0	114.9	89.0	109.1	83.4
Rakes	3.9	1.6							1.2	0.5	0.8	0.4	0.4	0.2		
Tongs and grabs									12.0	6.6	8.1	5.2	7.5	5.2	5.0	3.7
Wheels																
Hand (Oyster)									1.6	0.9						
Hand (Other)																

Appendix B. (continued)

Gears	1970		1971		1972		1973		1974		1975		1976		1977	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
Haul seines	1,601.0	251.0	1,258.5	196.5	1,779.8	314.6	3,122.5	594.0	3,145.7	521.2	3,878.5	574.0	4,327.5	696.5	3,277.8	435.4
Purse seines	256.2	48.3	72.5	13.6												
Trawls																
scallop													736.8	939.7	310.5	450.9
crab	3,144.3	170.1	1,266.7	101.1	742.3	74.0	1,251.3	174.5	554.6	64.5	1,338.0	208.7	1,548.3	308.7	1,245.6	277.5
shrimp			1,998.8	1,153.2	1,140.3	620.5	771.0	640.4	1,835.5	828.5	806.3	620.1	1,601.6	1,765.3	1,882.6	2,052.2
fish	2,465.0	521.7	3,050.7	684.5	2,917.6	545.2	4,210.0	870.4	6,331.3	1,327.9	9,939.0	2,263.2	11,891.7	2,351.3	14,075.1	3,664.7
lobster							1.7	2.5								
Pound nets	1,008.7	153.6	1,178.5	113.0	735.3	117.2	1,012.0	137.6	824.0	154.1	1,532.8	318.4	3,594.1	666.1	1,828.2	280.6
Fyke and hoop nets	16.3	2.3	17.8	2.5												
Pots and traps	8,036.1	512.9	7,139.0	564.0	6,883.5	724.9	6,733.9	894.7	7,871.3	943.0	5,258.2	731.3	4,710.6	1,103.5	6,332.0	1,111.7
Gill nets																
anchor, set or stake	914.9	158.4	851.2	143.8	945.0	177.8	689.6	147.2	1,019.0	201.9	1,049.8	253.2	1,148.9	318.5	1,055.0	336.1
drift	6.4	0.9	12.5	0.4	19.6	0.8	4.8	0.7	1.1	0.4	19.5	1.4			25.8	3.3
runaround	5.5	0.6	4.2	0.4	0.2	*	0.2	*	21.2	4.2					6.3	0.9
Lines																
hand	29.0	4.3	17.1	2.5	6.1	0.9	2.6	0.3	13.6	2.0	14.0	6.3	6.1	1.7	2.2	0.4
troll	8.4	1.8	5.0	1.3	0.8	0.2	4.4	1.1	8.3	4.8	60.0	36.0	132.8	92.7	235.4	119.8
longline	70.3	10.1	50.3	7.4	25.5	3.6	6.3	0.9	6.0	1.0	6.3	0.9	7.2	1.5	10.3	2.2
trot	1,601.9	108.5	1,041.4	78.8	769.0	81.6	163.8	20.1	238.4	24.3	210.7	25.1	457.9	97.4	271.5	47.1
Dip nets	36.2	1.5	16.6	4.7	3.0	1.5										
Spears	0.5	0.2														
Dredges	129.0	92.5	194.5	133.0	175.2	133.0	318.9	256.9	283.5	219.9	215.3	164.8	145.1	121.0	198.6	190.9
Rakes																
Tongs and grabs	22.1	16.2	7.0	4.9			2.7	2.4								
Wheels																
Hand (Oyster)																
Hand (Other)																

Appendix B. (continued)

Gears	1978** Pounds	1978** Value	1979** Pounds	1979** Value	1980** Pounds	1980** Value	1981** Pounds	1981** Value	1982** Pounds	1982** Value	1983** Pounds	1983** Value
Haul seines	5,073.6	651.0	8,902.4	1,604.9	10,469.9	2,027.0	8,884.7	2,427.8	7,361.0	2,300.4	7,517.7	2,112.1
Purse seines												
Trawls												
scallop	384.2	925.6	527.4	1,232.9	148.6	273.4						
crab	1,795.3	354.7	2,923.1	539.5	3,292.6	719.9	4,060.8	939.9	3,332.6	820.8	2,902.7	998.3
shrimp	1,110.6	752.9	976.8	770.5	2,381.0	3,432.6	1,023.8	986.2	2,105.2	3,289.6	1,100.8	1,716.6
fish	13,501.1	4,878.3	20,360.2	7,164.3	20,051.1	6,287.6	20,199.3	6,946.5	10,761.0	5,345.8	7,938.7	3,510.6
lobster												
Pound nets	2,513.3	386.6	1,807.9	323.6	6,278.7	1,453.7	4,293.7	1,265.4	4,833.1	1,382.5	2,588.5	740.5
Fyke and hoop nets												
Pots and traps	9,611.1	2,063.7	11,677.0	2,321.9	16,032.8	3,108.6	15,185.1	3,287.1	16,053.0	3,135.3	14,127.9	3,260.0
Gill nets												
anchor, set or stake	2,230.4	623.7	2,870.0	744.7	2,659.1	715.9	4,282.5	1,288.4	4,407.8	1,823.9	6,054.6	2,020.7
drift	39.5	1.6	14.8	7.9	0.1	*					11.0	1.7
runaround	2.5	0.5	0.9	0.1	35.7	6.9	23.4	4.5	9.6	1.6	38.0	5.9
Lines												
hand	5.7	1.7	8.1	4.3	22.5	18.6	8.8	7.9	188.6	175.2	97.3	92.1
troll	121.8	80.2	282.4	203.1	557.7	398.7	400.7	344.1	811.9	658.7	580.4	338.2
longline	20.8	33.9	0.5	0.6	166.3	212.2	125.1	160.1	40.4	91.5	8.7	23.8
trot	8.7	2.1	27.0	4.5					7.0	1.3	26.1	5.2
Dip nets	0.5	*	0.3	*	2.1	0.4	5.9	4.3	2.1	0.3	0.1	*
Spears					55.0	5.5			0.3	0.2		
Dredges	1,469.3	2,304.8	973.8	2,392.7	862.6	2,312.7	359.7	648.3	322.4	371.2	401.3	659.7
Rakes									3.3	14.8	7.4	27.7
Tongs and grabs					0.4	0.5	6.5	7.9	1.2	1.6	1.1	1.5
Wheels											0.3	0.5
Hand (Oyster)												
Hand (Other)	0.5	0.1										

*Denotes less than $100.00

**Preliminary landings. Data subject to revision in the Fishery Statistics of the U.S.